The University of Texas at El Paso
College of Engineering
Department of Electrical and Computer Engineering
Syllabus

EE 5373/4395 Introduction to Remote Sensing Systems
Credit Hours: 3
MW 1:30 to 2:50 pm, Fall 2017

Prerequisite Courses: (EE 3384 and EE 3353 and MATH 3323) or Permission of the instructor.

Course Description:
Introduction to imaging principles and system performance parameters for optical systems used in multi/hyperspectral remote sensing. Study and evaluation of existing and proposed ground-based, airborne, and satellite remote sensing platforms. Introduction to the end-to-end information processing chain including algorithms, methodologies and tools for information extraction and management in multi/hyperspectral remote sensing. Discussion of research trends in the area.

Instructor:
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Learning Outcomes:
After completion of this course, students should be able to:
- Understand the fundamentals of imaging for remote sensing applications using multispectral and hyperspectral imagers.
- Understand the parameters of the imaging system and how they affect the quality of the collected image
- Apply algorithms for atmospheric compensation, geo-referencing to remote sensing imagery
- Apply signal and image processing, and pattern recognition techniques to the analysis of remote sensing imagery.
- Use software tools such as ENVI/IDL or MATLAB for the analysis of remote sensing imagery

Required Materials:

Textbooks

Main: E. Chuvieco, **Fundamentals of Satellite Remote Sensing: An Environmental Approach**, 2nd Edition, CRC Press, 2016.

Secondary: R.A. Schowengerdt, **Remote Sensing: Models and Methods for Image Processing**, 3rd Edition, Elsevier, 2007. Available free from UTEP Library Electronic Resources (Inside UTEP or using VPM from home) :
http://0-www.netlibrary.com.lib.utep.edu/urlapi.asp?action=summary&v=1&bookid=196149
http://www.sciencedirect.com/science/book/9780123694072

References

1. D.G. Manolakis, R.B. Lockwood, and T.W. Cooley, **Hyperspectral Imaging Remote Sensing: Physics, Sensors, and Algorithms**, Cambridge Press, 2016.
2. R.C. Olsen, **Remote Sensing from Earth and Space**, 2nd edition, SPIE Press, 2016.
3. L. Alparone, B. Aiazzi, S. Baronti, A. Garzelli, **Remote Sensing Image Fusion**, CRC Press, 2015.
4. A. Garzelli, S. Baronti, B. Aiazzi and L. Alparone, **Remote Sensing Image Fusion**, CRC Press, 2015.
5. J.R. Jensen, **Introductory Digital Image Processing: A Remote Sensing Perspective**, 4th Edition, Prentice Hall, 2015
6. M.J. Canty, **Image Analysis, Classification and Change Detection in Remote Sensing: with Algorithms for ENVI/IDL and Python**, 3rd Edition, CRC Press, 2014. Available from: http://0-proquest.safaribooksonline.com.lib.utep.edu/9781466570375
7. F. Tupin, J. Inglada, and J.M. Nicolas, **Remote Sensing Imagery**, Wiley, 2014. Available from: http://encore.utep.edu/iii/encore/record/C__Rb2864589
8. Q. Weng, **Scale Issues in Remote Sensing**, Wiley 2014.
9. J.A. Richards, **Remote Sensing Digital Image Analysis: An Introduction**, 5th Edition, Springer Verlag, 2013.
10. C.I. Chang, **Hyperspectral Data Processing : Algorithm Design and Analysis,** Wiley, 2013.
11. A. Ennr, **Remote Sensing : Techniques, Applications and Technologies**, Nova Science Publishers, Inc., 2013.
12. M. Eismann, **Hyperspectral Remote Sensing**, SPIE Press Monograph, Vol PM210, 2012.
13. C.H. Chen, **Signal and Image Processing for Remote Sensing**, 2nd edition, CRC Press, 2012.
14. G. Camps-Valls, D. Tulia, L. Gomez-Chova, S. Jimenez, and J. Malo, **Remote Sensing Image Processing**, Morgan & Claypool Publishers, 2011.
15. J. Le Moigne, N.S. Netanyahu, R.D. Eastman, **Image registration for remote sensing**, Cambridge Press 2011.
16. J.B. Campbell, **Introduction to Remote Sensing**, 5th Edition, The Guilford Press, 2011.
17. B.E. Saleh, ed., **Introduction to Subsurface Sensing and Imaging Systems**, Cambridge University Press, 2011.
18. C. Ünsalan and K.L. Boyer, **Multispectral Satellite Image Understanding: From Land Classification to Building and Road Detection**, Springer, 2011.
19. K. Tempfi, N. Kerle, G.C. Huurneman, and L.L.F. Janssen, **Principles of Remote Sensing**, 4th edition, ITC Educational Textbook Series, The Netherlands, 2009. Available free from http://www.itc.nl/library/papers_2009/general/PrinciplesRemoteSensing.pdf
20. G. Camps-Valls and L. Bruzzone, **Kernel Methods for Remote Sensing Data Analysis**, Wiley 2009.
21. R.G. Congalton and K. Green, **Assessing the Accuracy of Remotely Sensed Data: Principles and Practices**, 2nd Edition, CRC Press, 2008.
22. J.R. Schott, **Remote Sensing: The Image Chain Approach**, 2nd edition, Oxford University Press, 2007 Available from: http://0-site.ebrary.com.lib.utep.edu/lib/utep/Top?id=10212103
23. D.A. Landgrebe, **Signal Theory Methods in Multispectral Remote Sensing**, John Wiley & Sons, 2003.
24. P. Mather and B. Tso, **Classification Methods for Remotely Sensed Data**, 2nd Edition, CRC Press, 2009.
25. J. Jensen, **Remote Sensing of the Environment : An Earth Resource Perspective**, 2nd edition, Prentice Hall, 2007.
26. C. Elachi, **Introduction to the Physics and Techniques of Remote Sensing**, 2nd edition, Wiley, 2006.
27. F.D. van der Meer and S.M. de Jong, **Remote Sensing Analysis: Including the Spatial Domain**, Springer, 2006.
28. J.B. Adams and A.R. Gillespie, **Remote sensing of landscapes with spectral images : a physical modeling approach**, Cambridge University Press, 2006.
29. K. Navulur, **Multispectral Image Analysis Using the Object-Oriented Paradigm**, CRC Press, 2006.
30. S. Liang, **Quantitative Remote Sensing of Land Surfaces**, John Wiley & Sons, 2004.

31. P.K. Varshney and M.K. Arora, **Advanced Image Processing Techniques for Remotely Sensed Hyperspectral Data**, Springer 2004.
32. C.I. Chang, **Hyperspectral Imaging: Techniques for Spectral Detection and Classification**, Kluwer Academic/Plenum Publisher, 2003.
33. F.D. van der Meer and S.M. de Jong, **Imaging Spectrometry: Basic Principles and Prospective Applications**, Kluwer Academic Publishers, 2003. Available from: http://encore.utep.edu/iii/encore/record/C__Rb3135013

Online Resources

1. Electronic access to multiple remote sensing journals is available online from the UTEP Library.
2. SEOS Project, **Introduction to Remote Sensing**, http://www.seos-project.eu/modules/remotesensing/remotesensing-c00-p01.html
3. **Landsat Science**. Available from: http://landsat.gsfc.nasa.gov/
4. **Landsat 8 (L8) Data Users Handbook**. Available from: https://landsat.usgs.gov/landsat-8-l8-data-users-handbook
5. **The Earth Observations Handbook**. http://www.eohandbook.com/
6. **Earth Science and Applications from Space:National Imperatives for the Next Decade and Beyond**, Committee on Earth Science and Applications from Space: A Community Assessment and Strategy for the Future, The National Academies Press, 2007. Available from http://www.nap.edu/catalog.php?record_id=11820
7. **Journal of Hyperspectral Remote Sensing**, https://doaj.org/toc/2237-2202
8. **Remote Sensing — Open Access Journal**, http://www.mdpi.com/journal/remotesensing

Software Tools

1. **ENVI Tutorials**.
2. Available from: http://www.harrisgeospatial.com/docs/Tutorials.html
3. **MATLAB Hyperspectral Image Analysis Toolbox (HIAT)** http://www.censsis.neu.edu/software/hyperspectral/hyperspectral.html
4. **MultiSpec: A Freeware Multispectral Image Data Analysis System** https://engineering.purdue.edu/~biehl/MultiSpec/
5. **Python for Remote Sensing:** Available from: http://blog.rtwilson.com/resources-for-learning-python-for-remote-sensing-or-switching-from-idl/
6. **The Remote Sensing and GIS Software Library (RSGISLib)**, http://www.rsgislib.org/
7. **ArcGIS Tutorials:** https://www.youtube.com/playlist?list=PLVFxXUWb3cXXoDNCMjilFngPOZPyrVWg8

Computer Usage

- Most homework will require the use of programs such as MATLAB or ENVI/IDL.
- ENVI/IDL student version can be purchase from http://www.exelisvis.com/Industries/Academic/Students/StudentLicenses.aspx
- MATLAB is available from My.Apps.UTEP.edu.
- MATLAB tutorials and books are available from the UTEP Library.
- Some homework may require the use of GIS software. ArcGIS is available in My.Apps.UTEP.edu

Course Policies:

Grading:
The final grade will be based in two tests (40%), homework (25%), literature review assignment (10%) and a Project (25%). You need to complete and hand in all work to pass the course. An incomplete grade is given only for a valid reason when arrangements have been made with me and only if the student was passing the course. Late course work will not be accepted. No make-up work will be given.

Grading Policy:

A: [90, 100]
B: [80, 90)
C: [70, 80)
D: [60, 70)
F: [0, 60)

Classroom Etiquette:
Part of being a professional is being on time and being prepared to do your job. This applies to your career as a student as much as it does to your future career as an engineer. You are expected to be in class and prepared to participate at the scheduled start time. Wireless devices are allowed in the classroom. It is recognized that devices of this sort provide emergency access for your family and loved ones. However, please use professional discretion with these devices. This includes shutting them off or setting them in the silent mode before coming to class. Do not use text messaging or web browser features while you are in class. If you must answer the phone, please do so after discretely leaving the room. You may return to class once your call is finished.

Cheating and Plagiarism:
Cheating is unethical and not acceptable. Plagiarism is using information or original wording in a paper without giving credit to the source of that information or wording: it is also not acceptable. Do not submit work under your name that you did not do yourself. You may not submit work for this class that you did for another class. If you are found to be cheating or plagiarizing, you will be subject to disciplinary action, per UTEP catalog policy.

Course Statements:

Center for Accommodations and Support Services (CASS):
If you have a disability and need classroom accommodations, please contact the Center for Accommodations and Support Services (CASS) at 747-5148, or by email to cass@utep.edu, or visit their office located in UTEP Union East, Room 106. For additional information, please visit the CASS website at www.sa.utep.edu/cass.

Civility:
We expect course business to be conducted in a civil manner. Disrespectful behavior towards the instructor or classmates is not acceptable. Any uncivil behavior in class will be subject to disciplinary actions per UTEP policy.

Course Schedule (Tentative):

Topic	**Recommended Reading** **Chu→ Chuvieco** **Sch. → Schowengerdt,**	**Assignments**
Introduction to remote sensing and a brief historical overview, course introduction	Chu & Sch: Ch. 1	TBD
Physics of remote sensing: introduction to radiometry, fundamental equation in different regions of the electromagnetic spectrum	Chu & Sch: Ch. 2	TBD
Sensing systems: camera systems, EO systems, detectors, samples of existing systems, sensor resolution	Chu & Sch: Ch.3	Hwk: Presentation on an existing multispectral or hyperspectral imaging system
Analyzing EO Satellite Images	Chu: Ch. 4	TBD
Visual Interpretation	Chu: Ch 5	Hwk: Visualization of MSI/HSI.
Data Models: Statistical models for multi/hyperspectral imagery. Simple visualization techniques using scatterplots and scattergrams. Noise models. Spatial statistics. Topographic and sensor effects.	Sch: Ch.4	Feature extraction. Extraction of histograms. Determination of image partial statistics.
Digital Image Processing: Enhancements and Corrections Contrast enhancement: single band, color composites.	Chu: 6.1-6.5 Sch: 5.6	Hwk: Contrast stretching single band images. Hwk: Color image contrast enhancement.
Correction and Calibration	Chu: 6.6-6.7 Sch. Ch. 7	Hwk: use of ENVI-FLAASH for atmospheric correction and georeferencing
Registration and Fusion	Chu: Ch. 6.8 Sch. Ch. 8	Hwk: Image registration Hwk: Spatial enhancement
Spectral transforms. Feature extractions from MSI/HSI	Chu: Ch. 7.1 Sch: Sections 5.1→5.5	Hwk: Feature extraction.
Image Classification	Chu: 7.2 Sch: Sections 9.1→9.8	Hwk: Classification of MSI
Multitemporal analysis	Chu: 7.3	Hwk: Change detection analysis

Topic	**Recommended Reading** **Chu→ Chuvieco** **Sch. → Schowengerdt,**	**Assignments**
Hyperspectral Image (HSI) Processing: extension of multispectral methods and dimensionality issues, unmixing, spectroscopy	Sch.9.8→9.9 Professor notes	Hwk: HSI classification Hwk: HSI unmixing and soft classification
Spatial processing: Linear and nonlinear filters. Edge detection. Fourier transforms. Scale-Space representations.	Chu: 7.4 Sch: Ch. 6	Hwk: per pixel processing Hwk: spatial processing.
Validation	Chu: Ch. 8	TBD
Introduction to GIS	Chu: Ch. 9	TBD