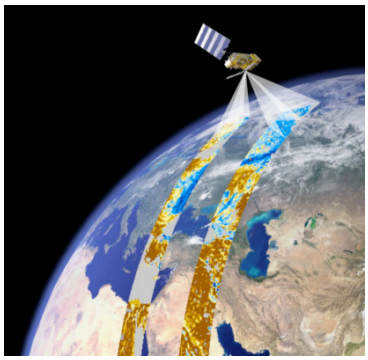
ASEN 6337 Remote Sensing Data Analysis



Lecture: T/TH 12:30-1:45pm, ECCR 151 (Lab: ECCR 239)
Webpage: Desire2Learn (https://learn.colorado.edu/)
Instructor: Prof. Tomoko Matsuo
Office Hour: T/TH 1:45-2:45pm or by appointment, ECOT 614

Course Description

With an explosive increase in the availability of high-resolution terrestrial remote sensing data, analyzing it has become a big data problem. Increasingly, machine learning is being recognized as a powerful tool for addressing this challenge. This course covers some of the most commonly used machine learning techniques in remote sensing data analysis, specifically for clustering, classification, feature extraction and dimensionality reduction. The course also covers inverse methods used to retrieve geophysical information from atmospheric remote sensing data. The course materials are organized into five sections: (1) Introduction, (2) Feature Extraction and Selection, (3) Clustering, (4) Classification, and (5) Inverse Methods for Atmospheric Remote Sensing Data. Hands-on computational homework (in Matlab or/and Python) and group and individual projects provide opportunities to apply classroom curricula to real remote sensing data.

Class Learning Goals

The goal of this course is to introduce commonly used machine learning techniques and inverse methods in remote sensing data analysis, equipping students with the knowledge and skills to apply modern data analysis techniques to remotely sensed data on their own. Students will: (1) develop a deeper understanding of machine learning and inverse methods in the context of remote sensing data analysis; (2) actively apply their own understanding of the fundamentals and tradeoffs of different approaches in critiquing current remote sensing data analysis research; and (3) develop the skills, confidence and creativity to design and solve a remote sensing data analysis problem of their choice.

Prerequisites

Some basic understanding of estimation theory and statistical learning techniques (e.g., ASEN 5044 Statistical Estimation for Dynamical Systems, ASEN 5307 Engineering Data Analysis Methods), as well as programming experience with Matlab or/and Python and familiarity with software engineering tools (e.g., GitHub) are desired.

Course Content

The class is broken into a number of sections, as follows:

- **Section 1: Introduction (Week 1-3)**
  - **Fundamentals of Remote Sensing**
  - **Remote Sensing Data Collection**
  - **Data Analysis and Statistical Learning Techniques**

- **Section 2: Feature Extraction and Selection (Week 4-5)**
  - **Principal Component Analysis**
  - **Kernel Methods**

- **Section 3: Clustering (Week 6-7)**
  - **K-Means**
  - **Iterative Self-Organizing Data Analysis Technique**
  - **Hierarchical Clustering**

- **Section 4: Classification (Week 8-10)**
  - **Bayesian classification**
  - **Neural Networks**
  - **Support Vector Machines**
  - **Tree Structured Classifier**
  - **Bragging and Random Forest**

- **Section 5: Inversion Methods for Atmospheric Remote Sensing Data (Week 11-14)**
  - **Abel Transform and Inversion**
  - **Review of Radiative Transfer, Weighting Functions, Averaging Kernels**
  - **Bayesian and Variational Methods**
  - **Temperature Profile Inversion**

- **Final project presentations (Week 15)**

Texts

All the reading material required for the course will be provided through the D2L course webpage. Suggested (not required) text books on the topics covered in this course include:

- Remote Sensing Handbook, edited by Thenkabail (2015) - *eBook at CU library*
- Introductory Digital Image Processing: A Remote Sensing Perspective, 4th ed, Jensen (2015) - *on reserve*
- Remote Sensing Digital Image Analysis, Richards (2013) - *eBook at CU library*
- Pattern Recognition and Machine Learning, Bishop (2006) - *on reserve*
- An Introduction to Statistical Learning, James (2013) - *eBook at CU library*
- Kernel Methods for Remote Sensing Data Analysis, edited by Camp-Valls and Bruzzone (2009) - *on reserve*
- Inverse Methods for Atmospheric Sounding: Theory and Practice, Rodgers (2000) - *on reserve*
- Occultations for Probing Atmosphere and Climate, edited by Kirchengast, Foelsche and Steiner (2004) - *eBook at CU library*

You can access these books as eBook from the CU library website, or some of them are placed on reserve in the CU Gemmill Library of Engineering, Math and Physics.

Class Format

The course will involve weekly lectures on the course content outlined above, as well as discussions of several key research articles. Homework assignments will provide opportunities to apply the data analysis techniques to real remote sensing data. A midterm take-home exam will be given to assess students' understanding and progress. Group and Individual projects will be required. Final oral and written reports of each student's project will be evaluated in terms of the soundness of a problem formulation, the quality and effort of research and analysis, the quality and clarity of oral and written presentations as well as the contributions to group work. Students are also asked to participate in peer reviews of the oral presentations as part of the final project evaluation.

Course Grading

5%	Participation in class discussion
20%	Homework (4 assignments or trades)
25%	Midterm take-home exam
25%	Group project (10% oral presentation and 15% written report, prorated by peer-evaluation)
25%	Individual project (10% oral presentation and 15% written report)
100%	Total

Late work is **NOT** accepted. There will be one 'makeup' homework opportunity at the end of semester.

Disabilities

If you qualify for accommodations because of a disability, please submit a letter to me from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322 or http://www.Colorado.EDU/disabilityservices

Religious Observances

Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, all dates for exams, assignments and presentations are fixed in the course schedule. Please review the course schedule and let me know if certain dates conflict with your religious obligations. See policy details at http://www.colorado.edu/policies/fac_relig.html

Classroom Behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment. Students who fail to adhere to behavioral standards may be subject to discipline. Faculty have the professional responsibility to treat students with understanding, dignity and respect, to guide classroom discussion and to set reasonable limits on the manner in which students express opinions. See policies at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

Academic Honor Code

As a student at the University of Colorado you are bound by an academic code of honor. The purpose of an Honor Code at the University of Colorado at Boulder is to secure an environment where academic integrity, and the resulting behavior, can flourish. The Honor Code recognizes the importance of honesty, trust, fairness, respect, and responsibility and wishes these principles to be a defining part of the CU-Boulder campus. The Honor Code allows all students to have responsibility for, and the ability to attain, appropriate recognition for their academic and personal achievements. A student-run Honor Code is necessary because research indicates that these institutions are highly successful in alleviating indiscretions and promoting an academically honorable community. In addressing any proven student violations regarding the Honor Code, the student leadership of the Honor Code Council applies only non-academic sanctions, and the faculty applies academic sanctions.

- Academic Dishonesty: Any of the following acts, when committed by a student at the University of Colorado at Boulder, shall constitute academic dishonesty:
  i. Plagiarism: Portrayal of another's work or ideas as one's own;
  ii. Cheating: Using unauthorized notes or study aids, allowing another party to do one's work/exam and turning in that work/exam as one's own; submitting the same or similar work in more than one course without permission from the course instructors;
  iii. Fabrication: Falsification or creation of data, research or resources, or altering a graded work without the prior consent of the course instructor;
  iv. Aid of Academic Dishonesty: Intentionally facilitating plagiarism, cheating, or fabrication;
  v. Lying: Deliberate falsification with the intent to deceive in written or verbal form as it applies to an academic submission;
  vi. Bribery: Providing, offering, or taking rewards in exchange for a grade, an assignment, or the aid of academic dishonesty;
  vii. Threat: An attempt to intimidate a student, staff, or faculty member for the purpose of receiving an unearned grade or in an effort to prevent the reporting of an Honor Code violation.

Violations of the Honor Code are acts of academic dishonesty and include but are not limited to: plagiarism, cheating, fabrication, aid of academic dishonesty, lying to course instructors, lying to representatives of the Honor Code, bribery or threats pertaining to academic matters, or an attempt to do any of the aforementioned violations. All incidents of academic

misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). **Any act of academic dishonesty will result in an F for this course** and will become a permanent part of the student's academic record.
For more information about the University of Colorado student honor code see
http://www.colorado.edu/policies/honor.html and at http://www.colorado.edu/academics/honorcode/

Plagiarism

This course includes a research project and final written report. In constructing the research paper it is expected that ideas and concepts will come from specific reference material. It must be demonstrated that this material supports the original premise of your research project and is properly referenced. Please examine the following guidelines to avoid committing plagiarism:

What is Plagiarism?, Georgetown University
How to avoid Plagiarism, Northwestern University
Plagiarism: What it is and how to recognize and avoid it, Indiana University

Discrimination and Harrasment

The University of Colorado at Boulder policy on Discrimination and Harassment, detailed at http://www.colorado.edu/policies/discrimination-and-harassment-policy-and-procedures, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships apply to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://hr.colorado.edu/dh/Pages/default.aspx.

Other Policies

Please be respectful of others during class time. This includes turning off your cell phone before class and not talking during class unless you have the floor. Details about all of the university policies can be found on the web at http://www.colorado.edu/policies/index.htm