MET 5970: Automated Analysis of Spatial Grids

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Class Hours: Tues, Thursdays 3.15-4.30pm in NWC 5820

Office Hours: 3-5pm Fridays (subject to modification) or by appointment at NWC 4457

Course Aims and Objectives:

The ability to create automated algorithms to process gridded spatial data is increasingly important as remotely sensed datasets increase in volume and frequency. This course provides students with a foundation in topics of digital image processing and data mining as applied to geospatial datasets. By the end of this course, students will be able to devise and implement automated techniques to extract information from spatial grids such as radar or satellite weather images.

Course Format:

The class consists of discussions and assigned projects. The instructor will lead discussions on image processing techniques and students will be expected to complete class assignments in order to gain a deeper understanding of the projects discussed in class. Lab work will involve the implementation of image processing algorithms to address specific objectives and can be carried out in the student's choice of programming language.

Textbook:

There is no assigned textbook for this class. Instead, students will be assigned journal papers available through the University of Oklahoma Libraries online resource.

Data Sets:

The image processing operations will be illustrated mostly on a population density dataset. Assignments will be carried out on the population density dataset and on a reanalysis dataset that is part of the 2013 AMS-AI competition.

Prerequisites:

Linear algebra and Introduction to Programming OR approval by instructor

Topics to be covered (subject to modification):

1. Introduction [slides in PDF]
    a. Why automated analysis?
    b. Challenges in automated analysis

    c. Image representation and analysis
2. Geospatial grids [slides in PDF]
    a. Objective analysis of point observations
    b. Remotely sensed data
    c. Bilinear interpolation
    d. Multi-radar combination
    e. Satellite navigation
    f. Map projections
    g. Mathematical and shape properties of map projections
3. Data structures for image analysis [slides in PDF]
    a. Matrix representation
    b. Markov chains
    c. Topology
    d. Relational structures
    e. Pyramids and quadtrees
    f. Parametric approximations
4. Global and local image statistics [slides in PDF]
    a. Metric and topological properties
    b. Histograms and PDFs
    c. Entropy
    d. Measures of noise
    e. Measures of texture
    f. Comparing images/forecast quality
5. Neighborhood operations [slides in PDF]
    a. Linear filtering
    b. Smoothing, edge detection, pattern matching
    c. Canny edge detection
    d. Distance operations
    e. Morphological operations
    f. Skeletonization
    g. Performance implications
6. Object identification [slides in PDF]
    a. Thresholds, hysteresis, optimal threshold
    b. Region-based segmentation
    c. Region growing
    d. Snakes and active contour algorithms
7. Change and motion estimation [slides in PDF]
    a. Cross-correlation
    b. Optical flow methods
    c. Object-based methods
    d. Hybrid methods
8. Transformations [slides in PDF]

a. Pixel coordinate transformations/warping
b. Fourier transforms/optimization
c. Watershed transform/segmentation
d. Hough transform/shape fitting
e. Discrete Cosine Transform/compression

9. Data Mining [slides in PDF]
    a. Attribute Extraction: Local, global, object-based and temporal statistics
    b. Machine learning
    c. Overfitting
    d. Decision trees
    e. Neural networks
    f. Bagging and boosting
10. Exam [slides in PDF]

Grading Plan:

Undergraduate students: course grade will be based on five lab assignments (80%) and an exam (20%).

Graduate students: course grade will be based on five lab assignments (60%), an exam (20%) and a term project (20%).

Letter grades are based on absolute points and will not be curved: A (100-90%), B (>= 80%), C (>= 70%), D (>= 60%), F (< 60%). Each lab assignment and term project is graded on a scale of 10 points. Late submissions are subject to a penalty of 2 points off per day. No credits will be given for assignments or projects that are late for more than 5 days, unless granted prior permissions. The exam will cover concepts covered in the class; the exact format of the exam (multiple-choice/short-answer/computer-project etc.) is subject to change. The topic of the term project (graduate students only) will be chosen by the student and approved by the instructor; the term project is due the week before end of classes.

All work should be submitted digitally to http://learn.ou.edu/. Reports should follow the format of conference papers of either the American Meteorological Society (AMS) or the IEEE. There is no paper submission for this class, except for the exam.

Academic Integrity

Each student in this course is expected to abide by Academic Integrity. The OU Academic Misconduct Code is available at http://www.ou.edu/provost/integrity. Students engaging in academic misconducts will be charged, or given admonitions for less serious cases. Any work submitted by a student in this course for academic credit will be the student's own work (except for group learning projects).

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students on lab assignments or activities.

However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else.

Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action. For materials from literature or the web, copying materials without quotations and paraphrasing words without citations are forms of “receiving inappropriate aid” by plagiarizing others’ ideas. The instructor will randomly send submissions at http://www.turnitin.com to check the degree of originality.

The exam is open-book and open-computer. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Accommodations for Students with Disabilities and Religious Observations

Any student in this course who has a disability that may prevent him or her from fully demonstrating his or her abilities should contact the instructor personally as soon as possible so accommodations can be made to ensure full participation and facilitate your educational opportunities.

It is the policy of the University to excuse absences of students that result from religious observations and to provide without penalty for the rescheduling of examinations and additional required classwork that may fall on religious holidays.