Hydroinformatics

USU CEE 6110, BYU CE En 594R, UofU CVEEN 7920

Class Time: Tuesday / Thursday 1:30 - 2:45 PM

Class Locations:

Utah State University: Distance Education 109
University of Utah: MBH 309
Brigham Young University: Clyde Building 234

Instructors:

Jeff Horsburgh
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Course Canvas Website

https://usu.instructure.com/courses/417249

Course Offering

This course will be simultaneously offered across the CI-WATER (http://ci-water.org) partner campuses (USU, UofU, BYU). Additional support is being provided by the iUTAH Project (http://www.iutahepscor.org). Each university has designated an instructor to manage things on their end, be present during class time, help deliver course content, and evaluate plus support work by students on their campus. Support for development of this course was provided by National Science Foundation Grants No. EPS 1135482, and EPS 1208732. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Course Overview

Hydroinformatics is the study, design, development, and deployment of hardware and software systems for hydrologic data collection, distribution, interpretation, and analysis to aid in the understanding and management of water in the natural and built environment. This class will introduce students to fundamental and advanced hydroinformatics concepts and procedures including automated data collection networks, relational databases and data management software, metadata and semantics, data storage file formats and standards, data transformations and automation of data manipulation tasks to support modeling and analysis, web based data distribution and access using web services, and integrated networks of hydro-climate data.

The course has an open, project-type format where students will work individually or in a small group over the semester to discover, organize and manage data for a hydrology or water resources problem of their interest. Projects may include designing appropriate data models and automating data loading, manipulation, and transformations in support of data intensive analyses or modeling. Class time will include lectures focused on learning and developing data management, transformation, and task automation skills, class discussions, code writing exercises to solve data manipulation tasks, demonstration of software and data systems, and student presentations of their project work. The course will better prepare students to work in data-intensive research and project work environments and emphasize development of reproducible processes for managing and transforming data in ways that others can easily and completely reproduce on their own to support analyses and modeling. Additionally, this course will better prepare students to work across multiple software platforms and systems used in data management.

Learning Objectives

Upon successfully completing this course, students will be able to:

Data and the Data Life Cycle:

1. Describe the data life cycle
2. Determine the dimensionality of a dataset, including the scale triplet of support, spacing and extent
3. Create basic programs for data collection using dataloggers and environmental sensors
4. Generate metadata and describe datasets to support data sharing
5. Discover and access data from major data sources

Databases and Data Models:

6. Store, retrieve, and use data from important data models used in Hydrology such as ArcHydro, NetCDF, and the Observations Data Model (ODM)
7. Develop data models to represent, organize, and store data
8. Design and use relational databases to organize, store, and manipulate data
9. Query, aggregate, and pivot data using Structured Query Language (SQL), Excel, R, and other software systems

Visualization, Transformations, Analysis, and Modeling:

10. Create reproducible data visualizations
11. Write and execute computer code to automate difficult and repetitive data related tasks
12. Manipulate data and transform it across file systems, flat files, databases, programming languages, etc.
13. Retrieve and use data from Web services
14. Organize data in a variety of platforms and systems common in hydrology and engineering

Prerequisites

Required:

- Graduate student standing
- Proficiency in Microsoft Excel

- Familiarity and ability to write simple programs in any programming language such as C, C++, C#, Fortran,Visual Basic, R, Matlab, Python, or Java.

Recommended:

- Concurrent or prior enrollment in a course on programming or databases, hydrologic modeling, integrated river basins/watershed planning and management, GIS in water resources, groundwater modeling, or related.
- Proficiency in Geographic Information System (GIS)

Texts

Required readings will be posted on this website or distributed in class.

Some potential references, but not required:

- Kumar, P., (2005), Hydroinformatics: Data Integrative Approaches in Computation, Analysis, and Modeling, CRC Press, 552 p.
- Grayson, R. and G. Blöschl, ed. (2000), Spatial Patterns in Catchment Hydrology: Observations and Modelling, Cambridge University Press, Cambridge, 432 p, full PDF text available at [http://www.catchment.crc.org.au/special_publications1.html (Links to an external site.)](http://www.catchment.crc.org.au/special_publications1.html).
- Tomer, S.K. (2012), Python in Hydrology, Grean Tea Press, Indian Institute of Science, 147 p. Full pDF text available at [http://www.greenteapress.com/pythonhydro/pythonhydro.html (Links to an external site.)](http://www.greenteapress.com/pythonhydro/pythonhydro.html).

Class Schedule

The class schedule will be maintained on the course website in Canvas. Please check the course Canvas page regularly for updates to the class schedule as it is subject to change. Lecture materials and assigned readings will be posted to the Canvas website.

Description of Required Course Work

Assignments

Students will complete a series individual assignments. Each assignment will pose a problem related to data organization, management, or transformation and will require use of software tools and/or computer programming/automation to solve. The list of assignments follows, but is subject to change:

- Assignment-1. Metadata, data management, and the data lifecycle
- Assignment-2. Datalogger programming and data collection
- Assignment-3. Data model design
- Assignment-4. Database implementation and loading data
- Assignment-5. Using Structured Query Language
- Assignment-6. Querying, visualizing, transformation, and analysis

- Assignment-7. Automation of data management tasks
- Assignment-8. Accessing data using Python and web services
- Assignment-9. Using R for hydrologic data analysis

Students will submit the answer to each assignment in the format of a 1-page engineering report or briefing paper. Each report should be formatted with standard 12-point font, 1-inch margins, and be fully self-contained to include an introduction to the problem, methods used, and results obtained so that a technically-versed reader not familiar with the problem statement can understand the rationale for, methods used, and results of the work presented. The restriction to 1 page is to help develop clear and succinct writing skills. Planners, managers, politicians, and decision makers rely on the work of engineers and hydroinformatics experts but are very busy people who rarely understand computer code or the underlying technologies. References, figures, tables, listing of code, and more detailed explanations can be included in appendices that do not count towards the 1-page limit. Students not satisfied with their performance on an assignment report may revise and resubmit it up to 1 week after the instructors evaluate and return the report.

Semester Project

Part of the course work will involve a semester-long project. Groups of up to 2 students will choose a hydrology or water resources data management problem to study for the semester. As part of the project, students will identify the data, data dimensionality, and lifecycle of the data required to solve the problem and develop metadata to describe and a data model to organize the data. Subsequently, students will implement the data model in a data management system and undertake querying, pivoting, and transformation activities to move the data into a model and/or analysis that uses the data. Students will report and make recommendations based on their results. Details of the semester project are available via the Course Canvas website.

Class Participation

We expect students to read assigned readings ahead of time and come to class and share their impressions of the reading(s) or ask questions on points they did not understand. At times, we may discuss readings in a seminar format. During lectures or discussions, the instructors will ask many questions, and, if needed, call on you individually to ensure everyone participates.

Grading of and Expectations for Submitted Work

Approximate Grading:

Assignments		50%
Semester Project		40%
Final project report	20%	
Peer review	5%	
Final oral presentation	15%	
Class Participation		10%

90 to 100% -- at least some sort of A
80 to 90% -- at least some sort of B
70 to 80% -- at least some sort of C
< 70% -- most probably some sort of F

There is no curve. All submitted work that meets grading rubric standards will earn an “A”.

All submitted work will be graded for technical correctness, organization, clarity, presentation, and other criteria according to the Grading Rubric available on the class website for the item. We will ask to meet with students who submit low quality work to discuss improvement strategies.

Submitted work must be:

- Original, typed with 1” margins in a standard 12-point font, printed, and stapled.
- Have a title page with title, student name(s), date, email address(es), class, and instructor.
- Handed in at the **beginning** of class on the due date listed on the class web page.
- Turned in with the self-assessment portion of the Grading Rubric completed.
- Turned in with the Group (and self) Rating Form completed (for group work items).
- Turned in with duplicate electronic copy and the self-assessment via Canvas.
- For group work, only one paper and Canvas copy need be submitted.
- **We do not accept late assignments.** They will be **graded as zero**. In extenuating circumstances (birth/death in the immediate family; grave illness with doctor’s note), contact the instructors **prior** to the due date and make alternative arrangements.

Academic Integrity: We expect each student to uphold academic integrity.

Expectations for academic integrity at each institution participating in this course are given on the following web sites:

- https://studentconduct.usu.edu/studentcode/article6
- http://registrar.byu.edu/catalog/2013-2014ucat/GeneralInfo/AcademicHonesty.php
- http://regulations.utah.edu/academics/6-400.php

USU, BYU, UofU, and the instructors take plagiarism seriously, and we will hold offending parties to the full extent of the individual university policies. When in doubt, acknowledge sources, cite references, and properly quote material that is not your own.

Electronic Policies

1. Class Webpage: We will post all class materials to the class webpage (this website in Canvas) including readings, lecture materials, and descriptions of and grading rubrics for all course work.
2. Canvas: Submit electronic versions of all work and self evaluations to Canvas (for grading and archiving purposes).
3. Project Reports: Please note that your project reports will be made publicly available on this Canvas website.

4. Email: **Include "Hydroinformatics" in the subject line** of all email so that we can timely attend and respond to emails. Unless you request that we don't, we may forward email questions and answers to the entire class.

Expectations of Students

- Be on-time to class and ready to learn / participate when class starts.
- Read assigned readings ahead of time and come to class prepared to share your impression(s) of the reading(s) and/or ask questions on points you do not understand.
- Turn off or keep silent all electronic devices that may distract the instructors or other students. We will ask students using phones, pagers, PDAs, music players, etc. to leave class.
- Contribute to class discussions while being respectful of and listening to others' points of view.
- Turn in all work on time in the required format.
- Bring questions and concerns forward during class, office hours, or by chat or email.
- Put in approximately 2 – 5 hours outside of class for each 1 hour of in-class time.

Expectations of the Instructors

- Start class on time.
- Respect the value of student's time.
- Call equally on all students for class participation.
- Learn student names by some point through the semester.
- Facilitate an environment of inclusivity and non-discrimination.
- Respond to email within 30 hours when we are not traveling out of town.
- Return graded work within 1 week from when work is submitted.

Disability/Special Accommodations

Please talk to one of the instructors immediately if you require disability or other special accommodations.

Additional Resources for Students

- Dr. Horsburgh's web page: http://jeffh.usu.edu
- Dr. Burian's web page: http://www.civil.utah.edu/~burian/
- Dr. Ames' web page: http://ceen.et.byu.edu/content/dan-ames

Please direct further questions or concerns about the syllabus or the course to one of the instructors by email, in person, or phone.