Course Title:

AMS 559: Smart Energy in the Information Age
Instructor: Zhenhua Liu
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Office Hours: Mon/Wed 6-7pm, online via Zoom
Lectures: Mon/Wed 4:25PM - 5:45PM, online

Course Description:

Energy and sustainability are among the greatest challenges faced by our society. While abundant renewable energy sources, such as wind and solar, provide the potential for sustainability, their intermittency and volatility present daunting operational challenges.

In recent years, there have been significant developments across scientific disciplines to address the above operational challenges. Some of these advances include predictions of renewable energy generation/electricity prices/power demand (statistics, machine learning), optimization of power grid control (operations research, electrical engineering), market and demand response program design (economics), and augmenting users' capability (cloud computing, Internet of Things/IoT). This course covers such research advances and focuses specifically on recent technologies and related real-world problems.

This course covers both techniques and applications in energy sustainability. On the techniques side, we will study popular techniques in machine learning, optimization, economics, and cloud computing/IoT. On the application side, we will first introduce issues that arise in energy and sustainability, followed by recent applications of the techniques we learned on energy problems. In particular, machine learning is used for predictions of renewable generation, electricity prices, etc; optimization is used for optimal power flow problem and energy procurement; economics is used in demand response program design; and cloud computing is used as an important component of IoT. If time allows, we will discuss some recent progress such as deep learning (AlphaGo, Libratus), as well as the applications of deep learning in energy. Examples include Google's leveraging of deep learning to improve data center cooling efficiency, and DeepMind's collaboration with UK National Grid.

Catalog Description

Energy and sustainability have become critical issues of our generation. While the abundant potential of renewable energy sources, such as solar and wind, provides a real opportunity for sustainability, their intermittency and uncertainty present a daunting operational challenge. This course studies how to use Information Technology (IT) to improve sustainability in our energy-hungry society. In particular, topics include the applications of mathematical modeling, algorithm design, optimization, game theory, and

control theory in real systems. The goal of the course is to provide rigorous foundations for the study of smart energy management for sustainability. *3 credits, Letter graded (A, A-, B+, etc.) No textbook required.*

Course Website:

http://www.ams.stonybrook.edu/~zhliu/AMS559 (from Fall 2017's offering)

Textbooks:

(recommended, not required)

1. The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Trevor Hastie, Robert Tibshirani, and Jerome Friedman. Springer 2009. (Online available here https://web.stanford.edu/~hastie/ElemStatLearn/)
2. Convex Optimization. Lieven Vandenberghe and Stephen P. Boyd. Cambridge 2008. (Online available here https://web.stanford.edu/~boyd/cvxbook/)
3. The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines, Second edition. Luiz André Barroso, Jimmy Clidaras, and Urs Hölzle. Morgan & Claypool Publishers. (doi:10.2200/S00516ED2V01Y201306CAC024)

There are many reports and technical papers in addition to the textbooks, e.g.,

1. The Smart Grid: An Introduction. Department of Energy. 2009. (Online available here https://energy.gov/oe/downloads/smart-grid-introduction-0)
2. Gubbi, Jayavardhana, et al. "Internet of Things (IoT): A vision, architectural elements, and future directions." Future generation computer systems 29.7 (2013): 1645-1660.

Syllabus:

The course will involve mostly lectures, a few hands-on demonstrations, and group presentations in class. The lectures will be based on textbooks and/or research papers on energy and sustainability topics. The first few lectures will give an overview of energy and smart grid, as well technologies such as machine learning, optimization, mechanism design, cloud computing, and Internet of Things. The subsequent lectures will take an in-depth look at each topic and provide more details. The rough breakdown of the syllabus can be found on the course webpage (http://www.ams.stonybrook.edu/~zhliu/AMS559).

Regarding machine learning, the course will cover both basic techniques, such as logistic regression, neural networks, SVM, dimensionality reduction, and how to apply these techniques in real applications in energy, such as predictions, anomaly detection, and de-aggregation. Similarly, basics of optimization and mechanism design will be covered with applications such as optimal power flow, unit commitment,

and demand response. Cloud computing and Internet of Things will be discussed with energy applications as well.

With the help of the DOE Great with Data project, we have revised most of the materials and added new materials. In particular, the slides for optimization and machine learning are completely new. We also developed slides from notes on learning basics and economics. There are four new lectures newly developed on energy-efficient computing, cyber physical security, deep learning for power system monitoring, and data science for smart grid.

Lecture periods: Course materials will be presented in a lecture-like format, where questions are welcomed and encouraged. Lecture periods will occur in person and online. Online lecture periods will be synchronous by default, occurring at the times listed above. Instructions for accessing online lecture periods will be posted to Blackboard.

Office hours: The instructor has each explicitly reserved time each week to be available for you to obtain extra assistance, ask questions, and discuss course materials. Instructions for accessing office hours will be posted to Blackboard. The instructor will also be reachable through email at other times.

Grading will be based on class participation and discussion (10%) + assignments (20% for assignment 1+20% for assignment 2) + remote presentation (10min, record using laptop or phone, 10%) + course project (40%). Details will be discussed in the first online lecture.

Information Dissemination: Due to unforeseen circumstances, this is a hybrid course delivered in both a traditional, face-to-face setting and a distance-learning setting. In both cases the Blackboard learning management system will be used. In Blackboard, you will access course materials and resources. Course materials posted to Blackboard include:

- This syllabus (updated, if needed).
- Slides and videos from lecture periods (only posted afterwards).
- Supplemental readings.
- Instructions for accessing online tools and components.
- Information on assignments and assessments.

Communication: Course-related questions should be posted to the appropriate forum in the course discussion boards on Blackboard. For personal/private issues, please use email, as listed at the top of this syllabus. If you use Blackboard's Email Tool, it will automatically include your full name, course name, and section when you send emails. The instructor strives to respond to your emails as soon as possible, but please allow 24–48 hours for a reply. Your Stony Brook University email must be used for all University related communications. All correspondence will be sent to your SBU email account.

Technical Assistance: If you need technical assistance at any time during the course or to report a problem with Blackboard you can:

- Visit the Stony Brook University Student Help Desk Page, http://www.stonybrook.edu/helpme
    - Phone:
        - (631) 632-2358 (technical support and Blackboard issues)
        - (631) 632-9800 (client support, wifi, software and hardware)
    - Create a ticket at http://service.stonybrook.edu.
- Students who need assistance with their personal devices can contact DoIT's service desk at (631) 632-9800 or submit an online request. For more information, visit: https://it.stonybrook.edu/students

Student Accessibility Support Center Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or via e-mail at: sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including

categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

Student Absences Statement

Students are expected to attend every class, report for examinations and submit major graded coursework as scheduled. If a student is unable to attend lecture(s), report for any exams or complete major graded coursework as scheduled due to extenuating circumstances, the student must contact the instructor as soon as possible. Students may be requested to provide documentation to support their absence and/or may be referred to the Student Support Team for assistance. Students will be provided reasonable accommodations for missed exams, assignments or projects due to significant illness, tragedy or other personal emergencies. In the instance of missed lectures or labs, the student is responsible for review posted slides, review recorded lectures, and seek notes from a classmate or identified class note taker. Please note, all students must follow Stony Brook, local, state and Centers for Disease Control and Prevention (CDC) guidelines to reduce the risk of transmission of COVID. For questions or more information click here.