ESE 589: Learning Systems for Engineering Applications

Instructor: Alex Doboli. PhD

Course Description: The course presents the main methods used in automated (machine) learning for engineering applications. The course discusses representation models for learning, extraction of frequent patterns, classification, clustering, and application of these techniques for diverse engineering applications, such as Internet-of-Things, electronic design automation, and healthcare. The covered topics include an overview of learning systems, learning representations i.e. ontologies, regression models, stochastic models and symbolic models, data preparing techniques, different frequent pattern extraction methods, supervised and unsupervised classification, and basic and advanced clustering algorithms. The course is organized as three modules, each module being centered on a specific theme.

Course objectives: Students will learn the characteristics of the enumerated topics, and devise and implement software programs for the discussed techniques as part of their project work for the course. Student projects will be assessed using standard benchmarks.

Catalog Description: The course presents the main methods used in automated (machine) learning for engineering applications. The course discusses representation models for learning, extraction of frequent patterns, classification, clustering, and application of these techniques for different engineering applications, like Internet-of-Things, electronic design automation, and healthcare. Supervised and unsupervised learning methods are discussed. The course includes extensive project work that involves devising and implementing the studied techniques and their evaluation using standard benchmark data.

Prerequisites: ESE 503 (stochastic systems). The prerequisites can be waived by the instructor upon request.

Course schedule: As a 3-credit course, it will meet either 3 times per week for one hour each, or twice per week for 90 minutes.

Interaction: The instructor will lecture using a videoconferencing system, like zoom. Office hours will be conducted synchronously using the same system.

No. credits: 3 credits

Grading: A B C F

Textbook:

- J. Han, M. Kamber, J. Pei, “Data Mining. Concepts and Techniques”, Third edition, Morgan Kaufman, 2012.
- V. Cherkassy, F. Mulier, “Learning from Data. Concepts, theory, and methods”. John Wiley & Sons, 2007 (reference).

Assignments: The course requirements include three projects. Each project corresponds to a module. It involves designing, implementing, and experimenting a main method used in automated learning. The first project is on mining frequent patterns, the second project on classification, and the third project on hierarchical clustering.

Students must prepare a detailed report of their project work including project description, description of the solutions and experimental results. Students must submit the project report and the software code of their implementation.

Course grading: The course is computed as follows: final exam (40%) + three course projects (20% each).

The following grading scale will be used: A: 90 and higher; B: 80-89; C: 65-79; F: 64 and bellow.

Academic Integrity Measure: Exams will be scheduled face-to-face on campus, if possible. Otherwise, exams will be carried out using a videoconferencing system, like zoom. Also, a significant part of the grade is based on course projects.

Covered topics:

A. **Module A**: Engineering knowledge representation

1. **Approaches in automated learning**: classical approach, adaptive learning;
2. **Representation (modeling) of engineering applications for automated learning**: ontologies, graph models, tradeoffs, regression models, statistical models; symbolic models;
3. **Data regularization frameworks**: approximation, penalization, model selection, data similarity and dissimilarity, data cleaning, data integration, data reduction, data summarization, data transformation, data discretization;
4. **Finding frequent patterns**: Apriori algorithm, pattern-growth method, mining using vertical data format;

B. **Module B**: Classification and clustering.

5. **Classification methods**: Decision Tree Induction, Bayes classification, rule-based classification;
6. **Advanced classification**: Backpropagation, Support Vector Machines;
7. **Clustering methods**: partitioning, hierarchical clustering, density-based methods;

C. **Module C**: Applications in Engineering

8. Learning causal information, belief networks, abstractions, time series
9. Application in IoT applications
10. Applications in design automation of electronic circuits and systems;
11. Application in healthcare and wellbeing

Electronic Communication Statement

Email and especially email sent via Blackboard (http://blackboard.stonybrook.edu) is one of the ways the faculty officially communicates with you for this course. It is your responsibility to make sure that you read your email in your official University email account. For most students that is Google Apps for Education (http://www.stonybrook.edu/mycloud), but you may verify your official Electronic Post Office (EPO) address at http://it.stonybrook.edu/help/kb/checking-or-changing-your-mail-forwarding-address-in-the-epo.

If you choose to forward your official University email to another off-campus account, faculty are not responsible for any undeliverable messages to your alternative personal accounts. You can set up Google Mail forwarding using these DoIT-provided instructions found

at http://it.stonybrook.edu/help/
kb/setting-up-mail-forwarding-in-google-mail.

If you need technical assistance, please contact Client Support at (631) 632-9800 or supportteam@stonybrook.edu.

Disability:

If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Disability Support Services, 128 ECC Building (631) 632-6748. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and Disability Support Services. For procedures and information go to the following web site: http://www.ehs.sunysb.edu and search Fire Safety and Evacuation and Disabilities.

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 are 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 Statement

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs 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.