**ME 8813 – Machine Learning Fundamentals for Mechanical Engineering**
**Spring 2023, 5:00pm – 6:15pm, Tuesday & Thursday**
**CLASSROOM: MRDC 2404 (ME 8813-WAN) & distance learning (ME 8813-Q)**

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| **FACULTY INSTRUCTORS** | Dr. Yan Wang<br>Phone: (404) 894-4714<br>Office: GTMI/MaRC, Room 472<br>E-mail: yan-wang@gatech.edu | Dr. Surya Kalidindi<br>Phone: (404) 385-0555<br>Office: Bunger Henry, Room 192<br>E-mail: surya.kalidindi@me.gatech.edu |
| **OFFICE HOURS** | by appointment | |
| **TAS** | Name: Daniel Hoover<br>Email: dhoover9@gatech.edu<br>Office Hour: by appointment | Name: Pranoy Ray<br>Email: pranoy@gatech.edu<br>Office Hour: by appointment |
| **PREREQUISITES** | Graduate standing, or permission of Instructors | |
| **CATALOG DESCRIPTION** | Introduction of machine learning methods and computational algorithms to solve mechanical engineering problems | |
| **OBJECTIVES** | - to introduce the fundamentals of machine learning and artificial intelligence including methods and algorithms<br>- to familiarize students with computational methods to solve engineering problems | |
| **TEXT BOOKS** | ▪ None | |
| **REFERENCE BOOKS** | ▪ Russell, Stuart J. and Norvig, Peter (2020) *Artificial Intelligence: A Modern Approach*, 4th edition, Prentice Hall.<br>▪ Bishop, Christopher M. (2006) *Pattern Recognition and Machine Learning*, Springer. | |
| **LIBRARY RESOURCES** | ME journals with papers in machine learning:<br>*ASME Journal of Computer and Information Science in Engineering*<br>*ASME Journal of Mechanical Design*<br>*Mechanical Systems & Signal Processing* | |
| **IMPORTANT DATES** | Last day to Add/Drop:  January 13 (Fri) 4pm<br>Last day to Withdraw:  March 15 (Wed) 4pm | |
| **CANVAS RULES** | • *Canvas* is the mandatory communication tool in this class. All class-related materials are posted there. *Canvas* is a web-based environment that enhances communications among students and between students and instructor.<br>• The *Discussions* area at *Canvas* provides a venue to give questions and answers. For any question that is general and not private or confidential, you should post it in the *Discussions* area first, instead of sending emails to instructors or TAs.<br>• Check *Canvas* often (e.g. once a day). Each student is responsible for keeping himself or herself informed with all announcements, assignments, course materials, and discussions.<br>• Each student is responsible for resolving any of misunderstanding **before** submissions of assignments and tests. No intention credit!<br>• Questions of how to use *Canvas* should be asked at:<br> http://canvas.gatech.edu | |

| GENERAL INFORMATION | Topics are given on the attached course outline. Each student is responsible for keeping current with all assigned course material and for resolving any area of misunderstanding. Questions should be resolved during class or by appointment with the instructors. |
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| GRADING | Homework                   (45%)<br>Interim Project Report    (20%)<br>Final Project Report      (35%) |
| MAKE-UP EXAM / QUIZ / PRESENTATION POLICY | Exams and presentations will be announced **at least two weeks** before the scheduled time. If you will miss any of the exams or presentations, please SEND the instructors AN EMAIL as written notice AT LEAST 12 HOURS IN ADVANCE before the scheduled time or due date. PROOF/DOCUMENT OF EMERGENCY is required to make an appointment for make-up. Students without **12-hour written notice** and **proof** will not be allowed to have make-up exams. |
| GRADE SCALES | Percentage Grade       GRADE               GRADE POINT VALUE<br>90-100                 A                      4.0<br>80-89                  B                      3.0<br>70-79                  C                      2.0<br>60-69                  D                      1.0<br>0-59                   F                      0.0 |
| INCOMPLETE grades policy | Incomplete grades are only given to students who have had a written agreement with the instructors at least *three weeks before* the final exam date. |
| SOFTWARE TOOL ACCESS | All recommended software packages for projects are open-source and freely available to students. Students can download and install in their own computers. |
| INCOMPLETE grades policy | Incomplete grades are only given to students who have had a written agreement with the instructors at least three weeks before the final exam date. |
| COMPUTER ACCESS AND ACCOUNTS | Computer use is intensive. Students should communicate via Canvas. Python based libraries will be used for assignments and projects. Make sure that you have access to python programing environment, such as Jupyter Notebooks, VScode, and pycharm, on your personal computer. |
| COMPUTER FILES AND MESSAGES<br><br>NOTE: FAILING TO ABIDE BY THESE INSTRUCTIONS WILL AFFECT THE RESPONSE TIME THUS YOUR GRADE! | Emails:<br>All course-related e-mails must have a descriptive subject field with: ME8813 LastName, FirstName and a brief description. Do not leave this field blank! Otherwise, the email may be regarded as a spam and deleted.<br>Example: ME8813 Smith, John  - Question on homework 2    e-mails start with the class number!<br>Computer Files:<br>All computer files must be named as follows:<br>ME8813_LastName_FirstName_BriefDescription.file type.<br>Example: ME8813_ Smith_John_HW1.doc<br>            ME8813_Smith_John_FinalProject_Presentation.ppt |
| GROUPS | All homework, projects, papers BY DEFAULT are individual efforts unless with explicit written notice in assignment specification, in which case student groups will be formed by the instructor. |
| ACADEMIC HONESTY<br><br>PLEASE KNOW YOUR RIGHTS AND OBLIGATIONS! LOOK INTO | Papers and Reports: Think independently and critically! Avoid plagiarism (see definition in the Scholarly Misconduct).  Make sure you give appropriate credit to the ideas and materials from other persons. If not sure about misconduct, seek advice of an Honor Advisor at:<br>http://www.honor.gatech.edu/plugins/content/index.php?id=18<br>Exams, quizzes, and individual assignments:  Unless stated in writing by the instructor, all exams, quizzes and assignments are individual work. Students are not allowed to "share" flow-charts, drawings, programs/codes, listings, or |

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| <br><br>**READ CAREFULLY THE HONOR CODE.** | results, even though you are encouraged to collaborate during the initial problem solving process. Note that for an experienced reviewer it is not difficult to detect "shared" logic! |
| **OFFICE OF STUDENT INTEGRITY** <br>HTTP://WWW.DEANOFSTUDENTS.GATECH.EDU/OSI/PLUGINS/CONTENT/INDEX.PHP?ID=66<br><br>**NOTE: THIS IS AN OFFICIAL GATECH NOTICE. PLEASE, THINK! YOUR PROFESSIONAL REPUTATION IS WORTH PROTECTING. IT TAKES A LIFETIME TO BUILD IT AND A MOMENT TO DESTROY IT. IN ADDITION, ONCE YOU LOSE YOUR REPUTATION, YOU WILL NOT RECOVER IT.** | YOUR ENROLLMENT STATUS MAY BE AT RISK!<br>Academic Dishonesty in any form will not be tolerated!!!<br>1. Cheating whereby non-permissible written, visual or oral assistance including that obtained from another student is utilized on examinations, course assignments or projects. The unauthorized possession or use of examination or course related material shall also constitute cheating.<br>2. Plagiarism whereby another's work is deliberately used or appropriated without any indication of the source. Thereby attempting to convey the impression that such work is the student's own. Any student failing to properly credit ideas or materials taken from another has plagiarized.<br>3. A student who has assisted another in any of the aforementioned breach of standards shall be considered equally culpable.<br>4. ACADEMIC SANCTIONS<br>  • Grade Penalty<br>    ○ Any assignments: zero ("0") in grade<br>    ○ Cheating in any test/exam: "F" in final grade)<br>  • Disciplinary Warning<br>  • Disciplinary Probation<br>  • Suspension Held in Abeyance<br>  • Suspension<br>  • Expulsion |
| **ACCOUTERMENTS (BOOK BAGS, SKATEBOARDS, COMPUTERS, CALCULATORS, ID'S)** | • Calculators – allowed during tests/exams<br>• Tape recorders and audio recording devices – allowed in class, NOT allowed during tests/exams<br>• Special tools or programs – allowed in class, NOT allowed during test/exams<br>• Cell phones – NOT allowed in class, NOT allowed during tests/exams |
| **DISABILITY ACCESS** <br>HTTP://WWW.ADAPTS.GATECH.EDU/ | Georgia Institute of Technology is committed to providing reasonable accommodations for all persons with disabilities. This syllabus is available in alternate formats upon request. Students with disabilities who need accommodations in this course must submit an ADAPTS accommodation letter to the professor within the first 4 weeks of the semester to request the needed accommodations. Otherwise, no accommodations will be provided throughout the semester. Students must contact the ADAPTS Office in 221 Smithgall Student Services Building to receive the ADAPTS accommodation letter. |
| **SUPPLEMENTAL ATTACHMENTS/HANDOUTS** | Available on Canvas as the course progresses. |
| **POLICY ABOUT DUE DATES** | Late assignments will be penalized 20% of total points per calendar day. That is, 20pts out of a total of 100 pts will be deducted per day. An assignment that is late for more than five calendar days will receive a zero ("0").<br>Distance Learning (Section Q) students are given 3 days (72 hours) grace period for late homework submission without penalty. |

## COURSE OUTLINE

| Week | Week of | Topic | Assignments due |
|---|---|---|---|
| 1 YW | 1/9 | **Introduction to AI and ML in Engineering** **hand-on Python tutorial** | |
| 2 YW | 1/16 | **Searching Algorithms** (breath-first search, depth-first search, greedy) | |
| 3 YW | 1/23 | **Optimization Algorithms** | |
| 4 SK | 1/30 | **Supervised Learning** (regression, LASSO) | HW1 due |
| 5 SK | 2/6 | **Supervised Learning** (support vector machine, Gaussian process) | |
| 6 SK | 2/13 | **Artificial Neural Networks** (back propagation, stochastic gradient) | |
| 7 SK | 2/20 | **Convolutional Neural Networks** (CNN architectures, applications) | HW2 due |
| 8 YW | 2/27 | **Uncertainty and Probabilistic Reasoning** (Dempster-Shafer, Bayesian belief network, MCMC) | |
| 9 YW | 3/6 | **Markov Models** (Markov chain, hidden Markov model) | |
| 10 YW | 3/13 | **Training Markov Models & Applications in Manufacturing** (E-M algorithm, Viterbi algorithm, Baum-Welch algorithm) | HW3 due |
| 11 | 3/20 | *Spring Break* | |
| 12 SK | 3/27 | **Unsupervised Learning** (k-means, self-organizing map, linear discriminant analysis) | Interim Project Report |
| 13 SK | 4/3 | **Unsupervised Learning** (linear and nonlinear dimensionality reductions) | |
| 14 YW | 4/10 | **Reinforcement Learning and Active Learning** (Markov decision making, Bayesian optimization-Gaussian process) | HW4 due |
| 15 YW | 4/17 | **Applications of Reinforcement Learning in Control** | |
| 16 | 4/24 | Final Project | Final Project Report |

Final Project
- Each student chooses a problem to solve. Own research is strongly encouraged. The deliverables include two reports. The interim project report defines the problem, proposes the methodology to solve, and summarizes the preliminary result. The final project report is comprehensive and includes the description of the problem, the relevant background and related work, the finalized methodology, the obtained results, and discussions about the results.
- The main evaluation criterion of the project is whether the result and final report are publishable.

Python packages for ML:
*scikit-learn* – common machine learning tools
*pyMC* – Bayesian inference with MCMC
*pomegranate* – Bayesian networks, Markov chains, hidden Markov models

**Learning Objectives**

1. Searching and Optimization
- *to familiarize with commonly used search algorithms for problem solving and optimization*

2. Statistical Machine Learning
 - *to familiar with the probabilistic reasoning methods and algorithms, including Bayesian belief network, MCMC, as well as Markov models and their trainings*

3. Artificial Neural Networks
 - *to familiarize with ANN and training algorithms*

4. Supervised Learning
- *to familiarize with regression models including logistics regression and Gaussian process and training methods*

5. Unsupervised Learning
- *to familiarize with formulations of clustering, classification, and dimensionality reduction*

6. Reinforcement Learning
- *to familiar with the concepts of utility and active learning.*