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School of Engineering

Course ID and Title: EE 638 – Applications of Machine Learning for Medical Data

Units: 4
Term—Day—Time: Spring— [M W 5:00–6:50pm]
Location: LVL 13

Instructor: Prof. Ajitesh Srivastava, Prof. Cauligi Raghavendra
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Catalogue Description
Application of machine learning models and algorithms to medical data, public health, smart grids, and computer systems. Dealing with data issues (poor quality, missingness), choosing the right ML algorithms, and evaluation.

Course Description
Application of machine learning models and algorithms to medical data, public health, smart grids, and computer systems. Issues and methods for handling real-world data with respect to missing and noisy data, choosing data preprocessing and machine learning techniques, and domain-specific evaluations. Techniques in image classification, time-series classification and regression, text mining, and graph neural networks. Applications include infectious disease forecasting for influenza and COVID-19, mental disorder classification including Alzheimer's, Autism, and cancer detection, challenges in computer systems (predicting memory accesses, program behavior), load forecasting in smart grids, and making a robot stand-up comedian. Students will learn how to deal with the challenges of real-world data through examples and reading papers.

Learning Objectives
  - Apply machine learning to real-world problems, including medicine, public health, smart systems, and computer systems;
  - Identify issues with real-world data and deal with them in analyzing data;
  - Perform literature search, conduct research, work on a team project, make presentations, write a paper, and write a peer review;
  - Evaluate and compare methods in real-world applications.

Prerequisite(s): EE 660 or CSCI 567 or DSCI 552 or other graduate-level Machine Learning course

Course Notes
Grading type: Letter
Material will be from papers and slides used in class. There will be guest lectures.

Technological Proficiency and Hardware/Software Required
Students are required to have familiarity with Matlab, Python, or other ML tools and coding languages of their choice. Access to Matlab is provided on campus. ML tools are publicly available. Students can use their own machines or use machines provided on campus.

Required Readings and Supplementary Materials

Required readings and supplementary materials are published journal and conference papers freely available at USC. Papers will be drawn on practical uses of machine learning and will cover publications that include machine learning, engineering, and public health conferences and journals. A list of papers is made available at the beginning of each semester.

Description of Assignments and How They Will Be Assessed

This is a research and project-oriented course. Students are required to choose a real-world application of their interest early in the semester and identify a specific problem. They will be given a list of possible ideas, links to websites, and access to a few guests/collaborators. Students will form project teams of 2-3. Each team will conduct a literature survey, learn about the application and the state-of-the-art, acquire data needed for their project (either from public sources or from mentors), design and apply machine learning to that problem, and perform evaluations. Students are expected to participate in class discussions, make short presentations during the semester, and make a final presentation on their project at the end of the semester. Each team will write a report and make a presentation of their project towards the end of the semester. There will be a homework problem to be done independently. Students will be graded based on the performance of their algorithm and the quality of the written report. The grade for the project write-ups, presentations, and the final report will be assigned to individuals based on their contributions. The first write-up is expected to be a 100-word abstract on the proposed project. The second write-up is expected to be a 2-page document covering an introduction and a related work section. The short presentations accompanying the write-up will be 5 minutes in duration. The final report will be a 10-page paper, and the final presentation will be 20 mins.

Grading Breakdown

Assessment Tool (assignments)	% of Grade
Write-up 1	10
Write-up 2	15
Homework	15
Short Presentations	10
Final Report	30
Final Presentation	20
TOTAL	100

Assignment Submission Policy

Assignments are assigned in class and submitted on Blackboard. Assignments are in the form of written reports and presentations.

Course-Specific Policies

In team assignments, each member should contribute to the success of the project. The contribution of each member is to be documented in the report. The expectation is for the project to be a publishable work.

Academic Integrity

Unless otherwise noted, this course will follow the expectations for academic integrity as stated in the USC Student Handbook. The general USC guidelines on Academic Integrity and Course Content Distribution are provided in the subsequent "Statement on Academic Conduct and Support Systems" section.

For this class, you are expected to collaborate on all the assignments except for the homework. Please ask the instructor if you are unsure about what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.

You may not record this class without the express permission of the instructor and all other students in the class. Distribution of any notes, recordings, exams, or other materials from a university class or lectures — other than for individual or class group study — is prohibited without the express permission of the instructor.

Use of Generative AI in this Course
Since technical writing is one of the learning objectives of this course, the use of AI-generated content (text or image) **is not permitted** in any of the submitted assignments. Use of such tools to write assignments will be identified as plagiarism and will be reported to the Office of Academic Integrity.

The use of AI-powered tools **is permitted** for assistance with writing code, exploring topics, and performing grammar checks. Learning to use AI is an emerging skill; this is an opportunity for you to discuss with the instructor the appropriate use of these tools. Keep in mind the following:
-   If you provide minimum-effort prompts, you will get low-quality results. You will need to refine your prompts to get good outcomes. This will take work.
-   Proceed with caution when using AI tools, and do not assume the information provided is accurate or trustworthy. If it gives you a number or fact: assume it is incorrect unless you either know the correct answer or can verify its accuracy with another source. You will be responsible for any errors or omissions provided by the tool. It works best for topics you understand.
-   AI is a tool, but one that you need to acknowledge using. Please include a paragraph at the end of any assignment explaining if, how, and why you used AI. Failure to do so is a violation of academic integrity policies.

Course Evaluations
A course evaluation will occur at the end of the semester, where you can provide a review of you experience in the class. The intent of the review is to identify which aspects of the class are liked by the students and which aspects should be improved in the future.

Course Schedule

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Introduction and overview of course, data, and tools to use Useful things to know about Machine Learning	Papers 1,2	Class discussion
Week 2	Machine Learning basics on structure and unstructured data; Machine learning and Data in medicine;	Papers 2, 3, 4	Class discussion
Week 3	Infectious disease forecasting, COVID-19, Influenza	Paper 7	Class discussion
Week 4	Ensembles and evaluations	Paper 8, 9	Choose topic and identify team Select papers on topic
Week 5	Image classification for Cancer, tumor detection, spine, Parkinson's disease Guest Lecture	Papers 9, 12, 14	Short write up on literature; Homework on applying Machine Learning to a public dataset
Week 6	Machine learning for mental disorders: Autism, Alzheimer	Paper 14, 15, 17	Short write up on project proposal and plan

	Alzheimer's disease and prediction; Short presentations by Student teams		
Week 7	Heart imaging, heart attack prediction, Treatment Recommendation Guest lecture	Papers 10, 12, 18	
Week 8	Connectome and brain networks, Graph machine learning	TBD	
Week 9	Lessons from other domains: Audio classification for Robot comedian Short presentations by student teams	Paper 20	Short project presentations
Week 10	Lessons from other domains: sequence prediction in memory systems, neural networks for compiler optimizations Guest lecture	Papers 22, 23	Class discussion
Week 11	Lessons from other domains: time-series problems in smartgrids Guest lecture	Paper 21	Class discussion
Week 12	How to write a paper Project progress review and discussions	Paper 24	Class discussion
Week 13	Project progress review and discussions		Class discussion
Week 14	**Project Presentations**		**Final Project Report Due; Each student team to make a presentation on their project**
Week 15	**Project Presentations**		**Each student team to make a presentation on their project**
FINAL			Refer to the final exam schedule in the USC Schedule of Classes at classes.usc.edu.

List of Papers

1. Tom Mitchell. The Discipline of Machine Learning.
   http://www.cs.cmu.edu/~tom/pubs/MachineLearning.pdf

2. Pedro Domingos . A Few Useful Things to Know about Machine Learning
   https://homes.cs.washington.edu/~pedrod/papers/cacm12.pdf

3. Kiri L. Wagstaff. Machine Learning that Matters. Proceedings ICML 2012.
http://www.icml.cc/2012/papers/298.pdf

4. Kenneth R Foster, Robert Koprowski and Joseph D Skufca. Machine learning, medical diagnosis, and biomedical engineering research – commentary. BioMedical Engineering OnLine 2014, 13:94.
http://biomedical-engineering-online.biomedcentral.com/articles/10.1186/1475-925X-13-94

5. George D. Magoulas, Andriana Prentza. Machine Learning in Medical Applications. Proceedings Machine Learning and Its Applications, Advanced Lectures Pages 300-307.
http://www.dcs.bbk.ac.uk/~gmagoulas/ACAI99_workshop.pdf

6. Wullianallur Raghupathi, Viju Raghupathi. Big data analytics in healthcare: promise. Health Information Science and Systems, 2014, 2:3 http://www.hissjournal.com/content/pdf/2047-2501-2-3.pdf

7. A. Srivastava, V. K. Prasanna. Fast and Accurate Forecasting of COVID-19 Deaths Using the SIkJα Model, https://arxiv.org/abs/2007.05180.

8. A. Srivastava, S. Singh, and F. Lee. Shape-based Evaluation of Epidemic Forecasts, IEEE BigData 2022, https://arxiv.org/abs/2209.04035

9. E. Cramer et. al. Evaluation of individual and ensemble probabilistic forecasts of COVID-19 mortality in the United States. Proceedings of the National Academy of Sciences, 2022.
https://www.pnas.org/doi/full/10.1073/pnas.2113561119

10. Lukasz A. Kurgana, Krzysztof J. Ciosa, Ryszard Tadeusiewicze, Marek Ogielae, Lucy S. Goodenday. Knowledge discovery approach to automated cardiac SPECT diagnosis. Artificial Intelligence in Medicine, Volume 23, Issue 2, October 2001, Pages 149–169.
http://www.sciencedirect.com/science/article/pii/S0933365701000823

11. J.A. Cruz, D.S. Wishart, Applications of Machine Learning in Cancer Prediction and Prognosis, Cancer Informat, 2 (2006), p. 59-77. http://www.la-press.com/redirect_file.php?fileId=150&filename=CIN-2-Wishart-et-al&fileType=pdf

12. Sesen MB, Kadir T, Alcantara RB, Fox J, Brady M. Survival prediction and treatment recommendation with Bayesian techniques in lung cancer. AMIA Annu Symp Proc. 2012;2012:838-47. Epub 2012 Nov 3.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3540451/

13. Fernando Yepes-Calderon, Fabian Pedregosae, Bertrand Thirione, Yalin Wang, and Natasha Lepore, Automatic pathology classification using a single feature machine learning - support vector machines.
http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1852210

14. Cyrus A. Raji, Kristen Willeumier, Derek Taylor, Robert Tarzwell, Andrew Newberg, Theodore A. Henderson, Daniel G. Amen, "Functional neuroimaging with default mode network regions distinguishes PTSD from TBI in a military veteran population," Brain Imaging and Behavior, 23 April 2015. http://link.springer.com/article/10.1007/s11682-015-9385-5/fulltext.html

15. Daniel G. Amen, Cyrus A. Raji, Kristen Willeumier, Derek Taylor, Robert Tarzwell, Andrew Newberg, Theodore A. Henderson, "Functional Neuroimaging Distinguishes Posttraumatic Stress Disorder from Traumatic Brain Injury in Focused and Large Community Datasets," PLoS One, July 2015.
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0129659

16. Ivo D. Dinov , Ben Heavner, Ming Tang et. al. Predictive Big Data Analytics: A Study of Parkinson's Disease Using Large, Complex, Heterogeneous, Incongruent, Multi-Source and Incomplete

Observations. PLoS One. August 2016.
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0157077

17. D. Bone D, M. S. Goodwin, M. P. Black, C. C. Lee, K. Audhkhasi, S. Narayanan, "Applying Machine Learning to Facilitate Autism Diagnostics: Pitfalls and Promises," J Autism and Developmental Disorders 2015 May;45(5):1121-36. doi: 10.1007/s10803-014-2268-6.
http://link.springer.com/article/10.1007%2Fs10803-014-2268-6

18. Lukasz A. Kurgan, Krzysztof J. Cios, Ryszard Tadeusiewicz, Marek Ogiela, Lucy S. Goodenday, "Knowledge discovery approach to automated cardiac SPECT diagnosis," Artificial Intelligence in Medicine 23 (2001) 149-169.
http://www.sciencedirect.com/science/article/pii/S0933365701000823/pdfft?md5=6aaa860dc02a2e1e6e2a8f6ad152e25a&pid=1-s2.0-S0933365701000823-main.pdf

19. John D. Medaglia, Mary-Ellen Lynall, and Danielle S. Bassett. Cognitive Network Neuroscience.
http://www.mitpressjournals.org/doi/pdf/10.1162/jocn_a_00810

20. C. Gray et al., ""This Bot Knows What I'm Talking About!" Human-Inspired Laughter Classification Methods for Adaptive Robotic Comedians," 2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), 2022, pp. 1007-1014, doi: 10.1109/RO-MAN53752.2022.9900634.

21. C.M. Cheung et. al., Behind-the-meter solar generation disaggregation using consumer mixture models, IEEE, In 2018 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm), 2018. https://ieeexplore.ieee.org/document/8587539/

22. Zhang et. al. ReSemble: Reinforced Ensemble Framework for Data Prefetching, In ACM/IEEE Supercomputing Conference (SC), 2022. https://www.computer.org/csdl/proceedings-article/sc/2022/544400b168/1I0bTdNcXjG

23. A. Srivastava et. al. Towards High Performance, Portability, and Productivity: Lightweight Augmented Neural Networks for Performance Prediction, IEEE, In 2020 IEEE 27th International Conference on High Performance Computing, Data, and Analytics (HiPC), 2020.
https://ieeexplore.ieee.org/document/9406682

24. https://www.cs.ucr.edu/~eamonn/Keogh_SIGKDD09_tutorial.pdf

https://www.alz.org/aaic/releases_2015/Sun-8amET.asp

http://time.com/3590494/alzheimers-blood-test/

Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recordings Policies
USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. (Living our Unifying Values: The USC Student Handbook, page 13).

Students and Disability Accommodations:
USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each

course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - *(213) 740-9355 – 24/7 on call*
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - *988 for both calls and text messages – 24/7 on call*
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - *(213) 740-9355(WELL) – 24/7 on call*
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - *(213) 740-5086*
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - *(213) 740-5086 or (213) 821-8298*
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - *(213) 740-0776*
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - *(213) 740-0411*
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - *(213) 740-2101*
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - *UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call*
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - *UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call*
Non-emergency assistance or information.

Office of the Ombuds - *(213) 821-9556 (UPC) / (323-442-0382 (HSC)*

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.