DSO 599 – Statistical Methodology and Machine Learning

Syllabus – Spring 2018 – Thursday – Times 6:30 to 9:20 (JKP Popovich 110) – 3 Units

Professor: Jason D. Lee
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Email: jasonlee@marshall.usc.edu
Office Hours: Thursday 5:30-6:30pm

Course Description
This class will serve as a rapid introduction to current topics in statistics and machine learning. The focus will be on the theory, methodology, and algorithms commonly used in modern statistics and machine learning. This class will cover linear algebra, stochastic optimization, and deep learning. The tentative topics are on page 3.

Learning Objectives
1. Learn the current set of statistical methodologies with a focus on algorithmic implementation and analysis.
2. Understand how the various methodologies and tools relate to decision-making.
3. Follow the newest developments in the fast-moving field of Machine Learning, and understand when an algorithm is applicable in a particular setting.

Required Materials
- Vershynin, Roman (2017). High Dimensional Probability
- Slides on Optimization, Estimation, and Deep Learning

Optional Material
- Bertsekas, Dimitris (1988). Nonlinear Programming

Prerequisites and/or Recommended Preparation:
Recommended Preparation: GSBA-506ab, GSBA-524, GSBA-516+545, or FBE-506GSBA 524. Experience with programming in Matlab or Python. Undergraduate level understanding of Linear Algebra, Probability, Optimization, and Analysis will be extremely helpful, but not required for those willing to put in additional effort.
# COURSE CALENDAR (Tentative)

<table>
<thead>
<tr>
<th>Week</th>
<th>1-8</th>
<th>Topics/ Daily Activities</th>
<th>Readings and Homework</th>
<th>Deliverables and Due Dates</th>
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<tbody>
<tr>
<td>Week 2</td>
<td>1-22</td>
<td>Methods from Linear Algebra (Perturbation Theory)</td>
<td>Slides</td>
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<tr>
<td>Week 3</td>
<td>1-29</td>
<td>Concentration Inequalities (Sub-gaussian RV, Subexp RV, Bernstein).</td>
<td>Vershynin 2017, 2.1 to 2.8</td>
<td>Assignment 1 Due</td>
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<tr>
<td>Week 4</td>
<td>2-5</td>
<td>Uniform Convergence (Epsilon-Net, Matrix concentration)</td>
<td>Vershynin 2011, 5.3-5.6</td>
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<tr>
<td>Week 5</td>
<td>2-12</td>
<td>Applications to Statistical Learning (Covariance Estimation, Matrix Completion, PCA, Graph Models)</td>
<td>Vershynin 2017, Chapter 10, Section 5.5, 6.5</td>
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<tr>
<td>Week 6</td>
<td>2-26</td>
<td>Stochastic Optimization (First-order Methods)</td>
<td>Bubeck Monograph</td>
<td>Assignment 2 due.</td>
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<tr>
<td>Week 7</td>
<td>3-5</td>
<td>Midterm</td>
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<td>Week 8</td>
<td>3-19</td>
<td>Matrix Factorization and Simple Neural Networks (Application to Recommenders)</td>
<td>Slides</td>
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<tr>
<td>Week 9</td>
<td>3-26</td>
<td>Backpropagation and Automatic Differentiation</td>
<td>Slides</td>
<td>Assignment 3 due.</td>
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<tr>
<td>Week 10</td>
<td>4-2</td>
<td>Generalization in Deep Learning and Applications in Vision</td>
<td>Slides</td>
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<tr>
<td>Week 11</td>
<td>4-9</td>
<td>Applications to Decision-Making (Bandit, MDP, RL)</td>
<td>Bubeck (Theory of Online Optimization)</td>
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<tr>
<td>Week 12</td>
<td>4-16</td>
<td>Applications in self-driving cars, robotics, planning</td>
<td>Assignment 4 due.</td>
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<td>Week 13</td>
<td>4-23</td>
<td>Implementation of Deep Learning in packages (Tensorflow, pytorch, keras)</td>
<td>In-class presentations Please note: The date/time of the Final Exam is determined by the University. For the date and time of the final for this class, consult the USC Schedule of Classes at <a href="http://www.usc.edu/soc">www.usc.edu/soc</a>. Select the corresponding semester to view and click on the “Final Examinations Schedule” link on the left side of the screen.</td>
<td>5 page report due.</td>
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**Course Notes:**
Slides and required materials will be posted on Blackboard.

**Grading Policies:**
1. Your final course grade will be assessed as follows:
   - Homework assignments (4 assignments each 7.5%) 30%
   - Presentations and report (Potential scribing of lecture notes) 30%
   - Midterm test 40%

2. **Team presentation and report.** We will have several in-class presentations by each student during the semester. You are expected to participate in the discussion. For the in-class presentation, students will present a recent monograph, tutorial, or paper that is relevant to the topics covered in the class. Students are also required to submit a 5-page Latex document summarizing the monograph/tutorial/paper. The in-class presentations will be evaluated by the quality of slides, presentation, and report. Students may work in teams of 2 for the in-class presentation and report.

3. **Class attendance and participation.** I strongly suggest that you attend all classes. They will give you a sense of what I feel is important in the class, as well as give you an opportunity to question ideas that do not make sense. I strongly encourage, as well as expect, questions during the classes. Besides the homework and exam grades, this is really my only source of information about how comfortable you are with the pace of the course. I will try to make the class as interesting as possible, but you need to give me feedback or I will assume that everyone is comfortable with the material and will keep moving forward. I have absolutely no problem going over a concept multiple times, so you should only be concerned with making sure you understand the material. If you feel uneasy bringing up your questions in class, take advantage of the many opportunities to speak with me one-on-one. I am always accessible by e-mail, and will be more than happy to speak with you before or after class or during office hours. Note: if your question requires a conversation rather than a short answer, email is not the best way to go – please talk to me after class or during office hours, and I will be happy to answer your question.

4. **Midterm test.** The midterm test will be given at the beginning of class on the date announced in the Course Schedule. You can bring textbooks, papers, and class notes to the test. **No make-ups of test will be given.** You will receive a grade of zero for the missed test unless you have an official written excuse from either your doctor or the University. An unexcused absence will result in a zero for the test.

5. **Working together.** Discussion of homework assignments is permitted and encouraged; however, each student is required to prepare and submit his/her own solutions, including computer output, independently. Duplication of homework solutions and computer output prepared in whole or in part by someone else is not acceptable and is considered plagiarism. Collaboration of any sort on exam is prohibited and will result in a zero for the exam. I reserve the right to bring any potential cheating issues to the administration for further penalties.
Retention of Graded Coursework
Midterm exams and all other graded work which affected the course grade will be retained for one year after the end of the course if the graded work has not been returned to the student. If I returned a graded paper to you, it is your responsibility to file it.

Assignment Submission Policy:
There will be 4 homework assignments that will involve computer programming and rigorous mathematical proofs. Homework is due at the beginning of class on the assigned date. Assignments should be written in Latex. Please use the standard article template in latex.
ADDITIONAL INFORMATION

USC Statements on Academic Conduct and Support Systems

Academic Conduct:
Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your
own words – is a serious academic offense with serious consequences. Please familiarize
yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior
Violating University Standards” https://policy.usc.edu/scampus-part-b/. Other forms of
academic dishonesty are equally unacceptable. See additional information in SCampus and
university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems
Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psycho-
therapy, group counseling, stress fitness workshops, and crisis intervention.
https://engemannshc.usc.edu/counseling/

National Suicide Prevention Lifeline - 1-800-273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional
distress 24 hours a day, 7 days a week. http://www.suicidepreventionlifeline.org

Relationship & Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on
call
Free and confidential therapy services, workshops, and training for situations related to
gender-based harm. https://engemannshc.usc.edu/rsvp/

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options,
and additional resources, visit the website: http://sarc.usc.edu/

Office of Equity and Diversity (OED)/Title IX compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected
class. https://equity.usc.edu/

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for ap-
propriate investigation and response. https://studentaffairs.usc.edu/bias-assessment-
response-support/

Student Support & Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success
as a student EX: personal, financial, and academic. https://studentaffairs.usc.edu/ssa/

Diversity at USC – https://diversity.usc.edu/
Tabs for Events, Programs and Training, Task Force (including representatives for each
school), Chronology, Participate, Resources for Students
Emergency Preparedness/Course Continuity

In case of a declared emergency if travel to campus is not feasible, the USC Emergency Information web site (http://emergency.usc.edu/) will provide safety and other information, including electronic means by which instructors will conduct class using a combination of USC’s Blackboard learning management system (blackboard.usc.edu), teleconferencing, and other technologies.

Students with Disabilities

USC is committed to making reasonable accommodations to assist individuals with disabilities in reaching their academic potential. If you have a disability which may impact your performance, attendance, or grades in this course and require accommodations, you must first register with the Office of Disability Services and Programs (www.usc.edu/disability). DSP provides certification for students with disabilities and helps arrange the relevant accommodations. Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to your TA) as early in the semester as possible. DSP is located in GFS (Grace Ford Salvatori Hall) 120 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776. Email: ability@usc.edu.

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Appendix III

Graduate Program Learning Goals

Explanation – A completed copy of this appendix or the equivalent using the Learning Objectives of the program for which the course is designed must be submitted along with the syllabus for all proposals for new or revised graduate courses. This is a Marshall requirement, not a University requirement. This document does not need to be part of the syllabus submitted with course proposals or distributed to students. MS program learning objectives are available at https://www.marshall.usc.edu/programs/specialized-masters-programs/ms-program-learning-objectives.
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<tr>
<th>Marshall Graduate Program Learning Goals</th>
<th>Objectives that support this goal</th>
<th>Assessment Method</th>
<th>Reporting Learning Outcomes</th>
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<tr>
<td><strong>Learning Goal #1:</strong> Our graduates will be impactful leaders who lead with integrity and purpose.</td>
<td>1.1 Possess a clear framework and commitment to an organization’s culture and core values, with personal integrity.</td>
<td>This course does not directly apply to these goals. However, the course learning objectives will help students in obtaining jobs, and succeed in the workplace by developing their analytical skills.</td>
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<td>1.2 Transcend traditional boundaries with a global mindset, drawing value from diversity and inclusion, and fostering community within and outside of organizations.</td>
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<td>1.3 Exhibit exceptional self-awareness through understanding of personal and career goals; awareness of individual strengths and weaknesses; and engagement in personalized, goal-driven, and lifelong learning.</td>
<td>1,2,3</td>
<td>Exam, Presentation and Report</td>
<td>Feedback on Exam Presentation and Report</td>
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<td><strong>Learning Goal #2:</strong> Our graduates will be impactful leaders who help identify and execute opportunities in uncertain and complex business environments.</td>
<td>1,2,3</td>
<td>Homework, Exam, and Presentation</td>
<td>Feedback on Exam, Homework, and Presentation</td>
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<tr>
<td>2.1 Apply an integrated approach to understanding and analyzing significant business problems, which can be complex, messy, unstructured, and beyond formulaic analysis.</td>
<td>1,2</td>
<td>Homework</td>
<td>Feedback on Homework</td>
</tr>
<tr>
<td>2.2 Use critical and analytical thinking to identify viable solutions that can create short-term and long-term value for organizations.</td>
<td>2,3</td>
<td>Homework, Exam</td>
<td>Feedback on Homework, Exam</td>
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<tr>
<td>2.3 Devise creative, sustainable, and achievable strategies and solutions that allow organizations to take advantage of opportunities that create value for its stakeholders.</td>
<td>1,2,3</td>
<td>Homework, Presentation</td>
<td>Feedback on Homework, Presentation</td>
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<td><strong>Learning Goal #3:</strong> Our graduates will be impactful leaders who achieve results by fostering collaboration on interpersonal, team, and organization levels.</td>
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<tr>
<td>3.1 Influence and motivate and work with colleagues, partners, and other stakeholders to achieve organizational purposes</td>
<td>3</td>
<td>Presentation and Report</td>
<td>Feedback on Presentation and Report</td>
</tr>
<tr>
<td>3.2 Help build and sustain high-performing teams by infusing teams with a variety of perspectives, talents, and skills and aligning individual success with team success and with overall organizational success</td>
<td>Not Applicable</td>
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3.3 Lead and participate in helping organizations adapt to a changing business landscape.

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<th>Bibliography for Slides:</th>
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| Not applicable |  |  |  |


