CSCI-4750/5750: Machine Learning

Syllabus

Fall 2020

Instructor Contact Information

Jie Hou, PhD
Assistant Professor
Department of Computer Science
Program of Bioinformatics and Computational Biology
Saint Louis University
Office: ISE 234G
Email: jie.hou@slu.edu

Office Hour: Thursday, 10:00 am-12:00 pm, or by appointment. The meetings will be held on Zoom (Same link as the class meeting)

Note: Please make sure to take advantage of office hours, as they offer a wonderful opportunity for individual attention.

Class Meetings

The material will be presented in three weekly lectures. Attendance is expected and class participation is most welcome. These meetings will offer learning opportunities that cannot be re-created purely from readings. In fact, you will get the most out of the meetings if you read the appropriate material in the textbook *before* the class meeting in which it will be discussed, and come prepared with any questions that you have. Information on the lecture topic can be found on the course schedule web page on Canvas.

- Class Periods: Mon/Wed/Fri, 11:00am-11:50am
- Classroom: ISE 230

Although attending lectures in the classroom is suggested, students that have requested attending online lectures also can join the lectures via Zoom. The lectures will be recorded and posted on Canvas for asynchronous learning.

https://slu.zoom.us/j/92292154274?pwd=ZjlyYndiSEN3cEtaZG5WQ3M4Vzdsdz09
Meeting ID: 922 9215 4274
Password: 417697

Course Description

This course introduces students to the field of machine learning with an emphasis on the probabilistic models that dominate contemporary applications. Students will discover how computers can learn from examples and extract salient patterns hidden in large data sets. The course will introduce classification algorithms that predict discrete states for variables as well as regression
algorithms that predict continuous values for variables. Attention will be given to both supervised and unsupervised settings in which (respectively) labeled training data is or is not available. Emphasis is placed on both the conceptual relationships between these different learning problems as well as the statistical models and computational methods used to employ those models.

Pre-requisites

For undergraduate students:

- Data Structures (CSCI2100)
- Calculus III (MATH 2530)
- Foundations of Statistics (STAT 3850)

Student Learning Objectives

After successfully completing this course, students will be able to:

1. Select a machine learning algorithm and model appropriate for a given problem, and apply an existing implementation to a real dataset
2. Formulate an appropriate evaluation scheme in order to tune model parameters and evaluate a solution;
3. Implement at least two machine learning algorithms from scratch
4. (CSCI 5750) apply machine learning techniques to solve a research problem in the student's major field

Topical Outline

Major themes within the course will include:

- What is Machine Learning?
- Decision Trees
- Nearest Neighbors
- Linear models and the Perceptron
- Non-linear methods (kernel methods, SVMs)
- Probabilistic models
- Ensemble Methods
- Clustering algorithms
- Expectation Maximization
- Introduction to Deep Learning
- Recurrent Neural Networks
- Convolutional Neural Networks

Course Textbook/Reading Materials

There are two useful textbooks for the course. The first one is Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurelien Geron. The SLU bookstore has copies available, or you can order the book from Amazon or directly from the publisher (O'Reilly). The Geron book comes with a series of excellent Jupyter notebooks that mirror the content of the book. I'll ask you to walk through and sometimes tweak these notebooks for homework as we make our way through the book. The second one is A Course in Machine Learning by Hal Daume III and is freely downloadable from the website.
Online Resources

Course Work

Most of the information for this course will be distributed only by means of the course web page, including all assignments, a schedule of lectures, detailed lecture notes and links to many other sources of information.

Email with Instructor

Zoom meeting in office hours is most desirable. Yet email is a convenient form of communication as well. I try to respond to email promptly, including at least once each evening when possible.

If your question involves your progress on a current programming assignment, my response will be more informative if you can point out the specific problem you have encountered, and if I am able to see all of your source code. Therefore I strongly suggest that you either attach all relevant files to the email or submit preliminary versions of such files through our online system.

Grading Scheme

<table>
<thead>
<tr>
<th>Course Item</th>
<th>Percent of Final Grade</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Homeworss</td>
<td>20%</td>
<td>There will be a series of homework and reading assignments during the semester, approximately once per week or two. These will include both questions that involve writing code and working with a dataset. I'm happy to look over your solutions in office hours to make sure you're on the right track. We expect there to be about 6-8 such assignments during the course. The homework grades will contribute equally to this portion of the grade.</td>
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<tr>
<td>Quizzes</td>
<td>20%</td>
<td>We will have biweekly quizzes to verify that you're doing the work outside of class. There will be six such quizzes, given at the beginning of class on Mondays (the exact dates are given on the course schedule), and each will cover the material from the two preceding weeks. The quizzes are usually true/false, multiple-choice, and some short answer, and only take about 10-15 minutes. I'll drop your lowest quiz score, but I will not allow you to make up quizzes that you miss because of absence or if you arrive late for class. Together the quizzes make up 20% of your final grade.</td>
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<tr>
<td>Course Projects</td>
<td>20%</td>
<td>You will also be asked to do a semester software project related to some topics we cover in the course, accounting for 45% of your final grade. I'll give you some ideas as we approach the middle of the semester. Since we cover a lot of different things, this is a good opportunity for you to explore some particular topics in greater depth. Students enrolled in CSCI 5750 are (1) required to work on a problem in their major area, and (2) their writeup should take the form of a publication-ready research paper, with an introduction, survey of related work, experiments, results, and a bibliography.</td>
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<tr>
<td>Midterm</td>
<td>15%</td>
<td>TBD</td>
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<tr>
<td>Final</td>
<td>20%</td>
<td>Wednesday, December 2, 8 to 9:50 a.m.</td>
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Course Participation | 5% | Attendance in class and interaction in or out of class will be counted for 5%.

Let me emphasize that just coming to class is not enough to be successful in this course. First of all, the only way to become a skilled Machine Learning practitioner is by actually working with real datasets, and that will be work mostly done outside of class. Secondly, there isn’t enough time for me to cover all of the theoretical details in ~40 class periods. You are responsible for understanding all of the material in the reading and homework assignments, even stuff not covered explicitly in the lecture. Again, if there is a material you are struggling with, do not hesitate to reach out during office hours or make an appointment with me.

Some of the assignments are required to complete with group members. Group members will be assigned and approved by the instructor. Group members need to contribute equally to the assignments.

| Total | 100% |

The final grades for the course will be based on the following scale. Letter grades will be based on each student's overall percentage of awarded points according to the following formula. The instructor reserves the right to make adjustments to grades based on overall performance in the course. There will be no opportunity for “extra credit” to improve grades that have already been earned. Bargaining for grades will not be tolerated.

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<tr>
<th>Letter Grade</th>
<th>F</th>
<th>D</th>
<th>C-</th>
<th>C</th>
<th>C+</th>
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<th>A-</th>
<th>A</th>
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<tr>
<td>Percentage(%)</td>
<td>&lt;60</td>
<td>≥60</td>
<td>≥67</td>
<td>≥70</td>
<td>≥73</td>
<td>≥77</td>
<td>≥80</td>
<td>≥83</td>
<td>≥87</td>
<td>≥90</td>
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Attending Policy

All exams must be taken promptly at the required time. Requests for rescheduling an exam will only be considered if the request is made prior to the start of the exam, or else in an "emergency" situation with appropriate documentation.

For homework assignments, we wish to allow students to continue to work comfortably beyond the official deadline when a little more time will result in more progress, while at the same time discourage students from falling significantly behind the pace and jeopardizing their success on future assignments. Our solution is the following exponentially decaying late formula (some have suggested that we should offer extra credit to anyone who fully understands this formula).

We will consider an assignment submission "complete" when any part of the assignment is last submitted or modified. Any assignment that is not complete promptly by its due date and time will be assessed a penalty based on the formula $S = R \cdot e^{-h/173}$, where $S$ is the grade given, $R$ is the grade the work would have received had it been turned in on time, and $h$ is the amount of time (in hours or fractions thereof) that the work was late.

Examples:
- work turned in 1 hour late receives 99.6% of its original credit
- work turned in 5 hours late receives over 97% credit
- work turned in one full day late receives less than 88% credit
- work turned in two full days late receives less than 76% credit
• work turned in five days late receives less than 50%.

The above policies will be waived only in an "emergency" situation with appropriate documentation.

## Tentative Schedule

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<tr>
<th>Dates</th>
<th>Topic</th>
<th>Homework</th>
<th>Announcements</th>
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<tr>
<td></td>
<td><strong>Week 1: Intro to Machine Learning</strong></td>
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<td>Aug 17: <strong>Intro to Machine Learning</strong> (What is machine learning; Machine learning concepts; Machine learning workflow, etc.)</td>
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<td>Aug 19: <strong>Linear Algebra in Jupyter, Numpy, Scikit-Learn</strong> (Vectors, Matrix, Eigenvalues/vectors, etc.)</td>
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<td>Aug 21: <strong>Data Science and Visualization in Python</strong> (Pandas, Matplotlib, etc.)</td>
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<td><strong>Week 2: Tree-based Classification/Regression</strong></td>
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<td>Aug 24: <strong>Decision Trees</strong> (Tree classification, Entropy)</td>
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<td>Aug 26: <strong>Train /Evaluate first classification trees</strong></td>
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<td>Aug 28: <strong>Trees for Regression</strong> (vs. Linear regression)</td>
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<td><strong>Week 3: Bias-Variance Tradeoff</strong></td>
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<td>Aug 31: <strong>Overfitting and Underfitting</strong> (Generalization errors, model complexity, bias, variance, diagnose, etc.)</td>
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<td>Sep 2: <strong>Model evaluation and Cross-validation,</strong></td>
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<td>Sep 4: <strong>Intro to Ensemble Learning</strong> (Bagging, Boosting, etc.)</td>
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<td><strong>Week 4: Ensemble Learning</strong></td>
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<td>Sep 7: <strong>Random Forest</strong></td>
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<td>Sep 9: <strong>Model Tuning in Scikit-Learn</strong> (Trees, Random Forests)</td>
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<td>Sep 11: <strong>In-class ML Practice</strong></td>
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<td><strong>Week 5: Supervised Learning Workflow</strong></td>
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<td>Sep 14: <strong>Steps to build first pipeline</strong> (feature engineering, bias-variance monitor, parameter tuning, evaluation)</td>
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<td>Sep 16: <strong>Data preprocessing in Scikit-Learn</strong> (dummy variables, missing data, imputing, scaling, etc.)</td>
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<td>Sep 18: <strong>Supervise Learning in Scikit-Learn</strong> (model</td>
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| Week 6: Linear Classifiers and Regularization techniques | Sep 21: **Loss Functions, Logistic Regression** (0-1 loss, hinge loss, etc.)  
Sep 23: **Logistic regression and Regularized** (Lasso, Ridge, etc.)  
Sep 25: **From Binary to Multi-class classification** (KNN, one-vs-rest, etc.) |
|-----------|------------------------------------------------------------------------------------------------------------------|
| Week 7: Model performance | Sep 28: **Measure model performance** (Recall, Precision, ROC curve, etc.)  
Sep 30: **Decision boundary visualization**  
Oct 2: **In-class ML Practice** |
| Week 8: Support Vector Machine | Oct 5: **Concepts of support vectors**  
Oct 7: **Kernel SVMs**  
Oct 9: **SVM tricks** |
| Week 9: ML Practice | Oct 12: **Practicum: Regression**  
Oct 14: **Practicum: Classification**  
Oct 16: **Midterm** |
| Week 10: Unsupervised Learning | Oct 19: **Unsupervised Learning**  
Oct 21: **Clustering algorithms** (hierarchical, k-means, t-SNE, etc.)  
Oct 23: **Dimension Reduction** (PCA) |
| Week 11: Intro to deep learning | Oct 26: **Deep Learning** (Neural network, feed-forward, activation, etc.)  
Oct 28: **Optimization and Gradient Descent** (regularization, dropout, SGD, Adam, etc.)  
Oct 30: **Build DL pipelines** |
| Week 12: Convolutional neural network | Nov 2: **Convolutional neural networks** (1D, 2D, kernels, convolution etc.)  
Nov 4: **How to go deeper?** (Parameters, poolings, dropout, etc.) |
| Week 13: Recurrent neural network | Nov 9: Recurrent neural network |
| Nov 11: GRU and LSTM cells |
| Nov 13: Application in Natural Language |
| Week 14: Machine learning in Bioinformatics | Nov 16: Protein secondary structure classification |
| Nov 18: Protein quality assessment regression |
| Nov 20: Protein contact/distance prediction |
| Week 15: Final Project Week |
| Week 16: Dec 2 |
| Final Exam, Wednesday, 8:00-9:50am |

**Syllabus Statements**

**Title IX**

Saint Louis University and its faculty are committed to supporting our students and seeking an environment that is free of bias, discrimination, and harassment. If you have encountered any form of sexual harassment, including sexual assault, stalking, domestic or dating violence, we encourage you to report this to the University. If you speak with a faculty member about an incident that involves a Title IX matter, **that faculty member must notify SLU’s Title IX Coordinator and share the basic facts of your experience.** This is true even if you ask the faculty member not to disclose the incident. The Title IX Coordinator will then be available to assist you in understanding all of your options and in connecting you with all possible resources on and off campus.

Anna Kratky is the Title IX Coordinator at Saint Louis University (DuBourg Hall, room 36; anna.kratky@slu.edu; 314-977-3886). If you wish to speak with a confidential source, you may contact the counselors at the University Counseling Center at 314-977-TALK or make an anonymous report through SLU’s Integrity Hotline by calling 1-877-525-5669 or online at http://www.lighthouse-services.com/slu. To view SLU’s policies, and for resources, please visit the following web addresses: [https://www.slu.edu/about/safety/sexual-assault-resources/index.php](https://www.slu.edu/about/safety/sexual-assault-resources/index.php) and [https://www.slu.edu/general-counsel](https://www.slu.edu/general-counsel).

**IMPORTANT UPDATE:** SLU’s Title IX Policy (formerly called the Sexual Misconduct Policy) has been significantly revised to adhere to a new federal law governing Title IX that was released on May 6, 2020. Please take a moment to review the new policy and information at the following web address: [https://www.slu.edu/about/safety/sexual-assault-resources/index.php](https://www.slu.edu/about/safety/sexual-assault-resources/index.php). Please contact the Anna Kratky, the Title IX Coordinator, with any questions or concerns.

**Note:** due to accreditation requirements, regulatory differences, and/or location-specific resources, the School of Law, the School of Medicine, and SLU Madrid have their own standard language for syllabus statements related to Title IX. Faculty in those units should seek guidance for syllabus requirements from their dean’s office.

**Disability Services**

Students with a documented disability who wish to request academic accommodations must contact Disability Services to discuss accommodation requests and eligibility requirements. Once successfully registered, the student also must notify the course instructor that they wish to access accommodations in the course.

Please contact Disability Services, located within the Student Success Center, at Disability_services@slu.edu or 314.977.3484 to schedule an appointment. Confidentiality will be observed in all inquiries. Once approved, information about the student’s eligibility for academic accommodations will be shared with course instructors via email from Disability Services and viewed within Banner via the instructor’s course roster.
Note: Students who do not have a documented disability but who think they may have one are encouraged to contact Disability Services.

**Academic Integrity**

*Academic integrity is honest, truthful and responsible conduct in all academic endeavors.* The mission of Saint Louis University is "the pursuit of truth for the greater glory of God and for the service of humanity." Accordingly, all acts of falsehood demean and compromise the corporate endeavors of teaching, research, health care, and community service via which SLU embodies its mission. The University strives to prepare students for lives of personal and professional integrity, and therefore regards all breaches of academic integrity as matters of serious concern.

The governing University-level Academic Integrity Policy was adopted in Spring 2015, and can be accessed on the Provost's Office website at: [https://www.slu.edu/provost/policies/academic-and-course/policy_academic-integrity_6-26-2015.pdf](https://www.slu.edu/provost/policies/academic-and-course/policy_academic-integrity_6-26-2015.pdf).

Additionally, each SLU College, School, and Center has adopted its own academic integrity policies, available on their respective websites. All SLU students are expected to know and abide by these policies, which detail definitions of violations, processes for reporting violations, sanctions, and appeals. Please direct questions about any facet of academic integrity to your faculty, the chair of the department of your academic program, or the Dean/Director of the College, School or Center in which your program is housed.

**Student Success Center**

In recognition that people learn in a variety of ways and that learning is influenced by multiple factors (e.g., prior experience, study skills, learning disability), resources to support student success are available on campus. The Student Success Center assists students with academic-related services and is located in the Busch Student Center (Suite, 331). Students can visit [https://www.slu.edu/life-at-slu/student-success-center/](https://www.slu.edu/life-at-slu/student-success-center/) to learn more about tutoring services, university writing services, disability services, and academic coaching.

**University Writing Services**

Students are encouraged to take advantage of University Writing Services in the Student Success Center; getting feedback benefits writers at all skill levels. Trained writing consultants can help with writing projects, multimedia projects, and oral presentations. University Writing Services offers one-on-one consultations that address everything from brainstorming and developing ideas to crafting strong sentences and documenting sources. For more information, visit [https://www.slu.edu/life-at-slu/student-success-center/](https://www.slu.edu/life-at-slu/student-success-center/) or call the Student Success Center at 314-977-3484.

**Face Masks Statement**

The University’s *Interim Policy on Face Masks* (visit [https://slu.policystat.com/policy/token_access/2e1e7d4c-49e9-42ba-8055-ca833711bea4/](https://slu.policystat.com/policy/token_access/2e1e7d4c-49e9-42ba-8055-ca833711bea4/)) governs all students, faculty, staff, and campus visitors in all University-owned, leased, or operated facilities. All persons physically present in any such University facility associated with this course shall comply fully with this policy at all times. Masks must be worn before entry to all such University facilities (as well as outdoors on all University property when six feet of distance is unpredictable or cannot be maintained).

Saint Louis University is committed to maintaining an inclusive and accessible environment. Individuals who are unable to wear a face mask due to medical reasons should contact the Office of Disability Services or Human Resources to initiate the accommodation process identified in the University’s *ADA Policy* (visit [https://www.slu.edu/human-resources/pdfs/policies/americans-disabilities-act-policy.pdf](https://www.slu.edu/human-resources/pdfs/policies/americans-disabilities-act-policy.pdf)). Inquiries or concerns may also be directed to the *Office of Institutional Equity and Diversity* ([https://www.slu.edu/general-counsel/institutional-equity-diversity/index.php](https://www.slu.edu/general-counsel/institutional-equity-diversity/index.php)). Notification to instructors of SLU-approved ADA accommodations should be made in writing prior to the first class session in any term (or as soon thereafter as possible).

As the instructor of this course, I shall comply fully with SLU’s policy and all related ADA regulations.

Students who attempt to enter a classroom without wearing masks will be asked by the instructor to wear masks prior to entry. Students who remove their masks at any time during a class session will be asked by the instructor to resume wearing their masks.

*Note: Accordingly, no consumption of any food will be allowed in class.*

Students who do not comply with a request by a SLU instructor to wear a mask in accordance with the University’s *Interim Policy on Face Masks* may be subject to disciplinary actions per the rules, regulations, and policies of Saint Louis University,
including but not limited to the *Student Handbook*. Non-compliance with this policy may result in disciplinary action, up to and including any of the following:

- dismissal from the course(s)
- removal from campus housing (if applicable)
- dismissal from the University

To immediately protect the health and well-being of all students, instructors, and staff, instructors reserve the right to cancel or terminate any class session at which any student fails to comply with faculty or staff requests to wear a mask in accordance with University policy. Students are strongly encouraged to identify to their instructor any student or instructor, not in compliance. Non-compliance may be anonymously reported via the SLU Integrity Hotline at 1-877-525-5669 (or confidentially via the Integrity Hotline's website at [http://www.lighthouse-services.com/slu](http://www.lighthouse-services.com/slu)).

**Attendance**

The health and well-being of SLU’s students, staff, and faculty are critical concerns. Accordingly, the following University policy statements on in-person class attendance are designed to preserve and advance the collective health and well-being of our institutional constituencies.

1. Students who exhibit any **potential COVID symptoms** (those that cannot be attributed to some other medical condition the students are known to have, such as allergies, asthma, etc.) shall absent themselves from any in-person class attendance or in-person participation in any class-related activity until they have been evaluated by a qualified medical official. Students should contact the [University Student Health Center](http://www.lighthouse-services.com/slu) for immediate assistance.

2. Students who exhibit any **potential COVID symptoms** (those that cannot be attributed to some other medical condition the students are known to have, such as allergies, asthma, etc.) but who feel well enough to a) attend the course synchronously in an online class session or b) participate in asynchronous online class activities, are expected to do so. Those who do not feel well enough to do so should absent themselves accordingly.

3. Students (whether exhibiting any of potential COVID symptoms or not, and regardless of how they feel) who are under either an isolation or quarantine directive issued by a qualified health official must absent themselves from all in-person course activity per the stipulations of the isolation or quarantine directive. They are expected to participate in synchronous or asynchronous online class activities as they feel able to do so, or absent themselves accordingly.

4. Students are responsible for notifying each instructor of an absence as far in advance as possible; when an advance notification is not possible, students are responsible for notifying each instructor as soon after the absence as possible.

5. As a temporary amendment to the current [University Attendance Policy](http://www.lighthouse-services.com/slu), all absences due to illness or an isolation/quarantine directive issued by a qualified health official shall be considered “Authorized” absences (effective August 2020 through May 2021).

**Distance Education Etiquette**

Your actions in distance education contexts are just as important as in on-ground, face-to-face educational contexts – and sometimes require additional attention and commitment, as some distance education technologies might be less familiar to us. Accordingly, all students are expected to follow the guidelines below:

**Synchronous Video Contexts (Zoom, etc.)**

1. Mute your microphone when you are not speaking. Remember to “un-mute” yourself just prior to speaking.
2. Identify yourself when you begin speaking.
3. Expect a few seconds of delay in getting a response from the instructor or another class member to a question; wait before repeating your question or assuming it was not heard.
4. If possible, position your camera such that your video feed does not capture too much of your surroundings or other activity/sound from your home/location. Be conscious of posters, art, or other surroundings that others might find offensive or inappropriate for an educational context.
5. Use the “Raise Hand” and “Chat” (or similar) features of your video-conferencing tool. This limits verbal interruptions and the confusion generated when multiple people try to speak at once.
6. Just as in an on-ground, face-to-face class, limit side conversations, multi-tasking (on your computer or otherwise), and use of your cellphone.
7. Temporarily turn off your video feed and mute your microphone when engaged in any non-class conversation or activity.
8. Respect and be attentive to the diversity of your classmates and instructor. Before communicating, consider your message in the context of the class’ diversity in race, ethnicity, religion, disabilities, gender, sexual orientation, age, social class, marital status, geography, etc. Consider the diversity you can see or know – as well as that you cannot.
8. Remember that video-based class sessions (including chat transcripts) may be recorded and retrieved for later viewing.

**Non-Video & Asynchronous Contexts (Blackboard, Canvas, Online Chats, Discussion Boards, etc.)**

1. When using the “Chat” or “Discussion Board” (or similar) features of your course management system, remember that your course-related communications to the instructor or other students should be considered “professional” (they are not like texts to your friends). Remember that course context and all related written work – including chat and discussion board transcripts – can be recorded and retrieved.

2. Be cautious when using humor or sarcasm; without the context of facial expressions or other body languages, your tone or intent could be missed or misunderstood by others.

3. Respect and be attentive to the diversity of your classmates and instructor. Before communicating, consider your message in the context of the class’ diversity in race, ethnicity, religion, disabilities, gender, sexual orientation, age, social class, marital status, geography, etc. Consider the diversity you can see or know – as well as that you cannot.

4. Respect others’ time and life circumstances, which often don’t allow for an immediate response to a question or comment.