



# SYDE675

## Pattern Recognition

Lectures: Tuesdays (E7-4437), Thursdays (E7-4053) 1:00-2:20 pm  
[online as per covid first few weeks)



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TA office hours tbd

This syllabus may be slightly updated during the course of the term.

**Course Description:** Pattern Recognition and Machine Learning (PRML) is a dynamic field that lies at the intersection of statistics and computational sciences. The goal of PRML is to develop algorithms that can "learn" from data using statistical and computational methods. The course will provide an introduction to this field and touch upon the recent interest in deep learning.

**Credit Hours:** 0.5 academic units

**Required Text(s):** can be downloaded from link for free or can be purchased online.

1. Christopher Bishop (2006). Pattern Recognition and Machine Learning, Springer. downloaded from PRML book download
2. Kevin P. Murphy (2022). Probabilistic Machine Learning. MIT Press. website

**Other Recommended Resource(s):**

1. C. Bishop implemented algorithms in python by CTGK: notebook, code
2. Hanington, B., Martin, B. (2012). Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions. Rockport Publishers.
3. Trevor Hastie, Robert Tibshirani and Jerome Friedman (2009), The Elements of Statistical Learning, Springer. website
4. Richard O. Duda Peter E. Hart and David G. Stork (2000). Pattern Classification, Wiley. website

5. David MacKay . (2003). Information Theory, Inference and Learning Algorithms, Cambridge. website

### **Student Expectations:**

The following are expected of the students

1. read the required readings before the lecture.
2. go over the pre-requisite background material before starting the course.
  - (a) Review of Probability Theory
  - (b) Linear Algebra review
  - (c) The Matrix Cookbook
  - (d) Bishop: Appendices B,C.
  - (e) An Introduction to Probability with Python
3. meet all deadlines and not be late,
4. work individually and adhere to University regulations.

### **Course Objectives:**

At the completion of this course, students will be able to:

1. be comfortable with classification and regression pattern recognition methods,
2. be able to define a problem, perform setup for the problem and utilize the proper tools to solve,
3. be comfortable with various algorithms and approaches covered,
4. be comfortable with practical aspects of deep learning systems.

### **Format:**

**Course website:** Available through <http://learn.uwaterloo.ca> for the purpose of distributing slides, videos, assignments and announcements. Please ensure your email settings are up to date so that you receive messages sent to the class. Lecture slides will be available from the "Content" menu while assignments will be accessible from the "Submit" menu and "Dropbox" submenu. **Lecture slides/notes will be uploaded on Learn.l.**

**Software:** Students are required to use Python for modelling assignments and projects. Download Python and install on your computer.

**Course Discussions:** On Learn, there is a discussion site blog to post questions for the prof. This is to be shared by the class.

**Assignments:** On Learn, Under the heading "Submit", under the heading of "Dropbox". is where you will find all assignments to be completed. Most assignments will also be uploaded here by the deadline posted.

### **Project:**

Project: You will need to pick a problem; a dataset to use; a classical PRML algorithm to use and compare it to a DL method. Details will be finalized in Feb.

### **Readings:**

see outline below.

## Outline:

1. Week 1
  - Introduction. (Reading: Bishop: 1,2; Murphy foundation chapters 2-8)
2. Week 2
  - Linear Models for Regression (Bishop 3; Murphy 4, 11)
3. Week 3
  - Bayesian Decision (Bishop 1.2, 2.3, 3.3; Murphy 3-5)
4. Week 4
  - Linear Model Classifiers (Bishop 4, Murphy 4-5)
5. Week 5
  - Linear Models (Bishop 3,4; Murphy 9-12)
6. Week 6
  - Linear Models (Bishop 3,4; Murphy 9-12)
7. Week 7
  - Non parametric models (KNN) (Murphy 16)
8. Week 8
  - Kernels (SVM) (Bishop 6; Murphy 17)
  - Clustering (Murphy 21)
9. Week 9
  - Decision Trees (Murphy 18)
10. Week 10
  - Dimensionality Reduction (PCA, ICA) (Bishop 12; Murphy 20)
11. Week 11
  - Neural Networks (Bishop 5; Murphy 13-15)
12. Week 12
  - Deep Neural Networks (Murphy 13-15)

## Grade Distribution:

- Mathematical Exercises (4) 25%

- Programming Exercises [Google Colab, Python] (6). 40%.
- Project Plan 5%
- Project 30%

### **Important Dates:**

- various assignments (math, programming): due dates will be posted on Learn in the dropbox
- Project Plan (problem, data set, SOTA literature review (1 page): due March 8, 2022.
- Project will be due exactly 2 weeks after classes end, at midnight. (April 19, 2022) Students will have to submit a 6 page paper (CVPR format) and colab code that they will have to demonstrate to the TA or myself before that deadline.

### **Collaboration Rule:**

Students are encouraged to discuss individual assignment exercises with each other and the course instructor. Any assistance must be limited to discussion of the problem and sketching general approaches to a solution. Each student must write their own individual solutions, including codes and text. Consulting another student's solution is prohibited and submitted solutions may not be copies from any source. In particular, submitting solutions copied in whole or in part from an assignment submission or solution key from any offering of a similar course is prohibited, even if the student is resubmitting their own work. These and any other forms of collaboration on assignments constitute cheating.

### **Principles for our SYDE-BME Community (faculty, staff, and students):**

1) Be compassionate. 2) Be accountable. 3) Be patient. 4) Be safe and healthy.

**Compassionate and respectful communication:** Most online communication between the Department and students will be done through LEARN and/or email. Students are reminded that they should now use their email account name@uwaterloo.ca. Include an academic signature with your full name, program, student ID. We encourage you to include your preferred pronouns (he/him; she/her; they/them).

**Scheduling of Synchronous (live) online course events:** Due to the COVID-19 pandemic, all University of Waterloo courses components will be delivered online, until further notice. To maintain build supportive teaching environments, instructors may use the time slots (EDT) scheduled ?in-class? hours to hold ?live-stream? events such as lectures, tutorial help sessions, group activities, and open office hours. To accommodate different time zones, different working/studying conditions and limitations in internet access, all critical course components, including lectures and student support must be made available in asynchronous formats. Any timed component (for example: a test or quiz) must take time zone and internet availability into account.

**SYDE-BME COMMENT ON ACCOMMODATION:** We respect that our SYDE-BME students are independent adult decision-makers, with many opportunities to partake in activities that might be in time conflict with academic deadlines and deliverables. Along with the right to make

adult decisions comes the responsibility and accountability for those decisions and any outcomes. The University of Waterloo's policy on accommodation for missed deliverables pertains to verifiable health matters, and highly unfortunate events (for example: family tragedies). The Department of Systems Design Engineering follows University of Waterloo's general policy: students who self-elect to forgo a deliverable receive a "0" for that deliverable. It is preferred practice so that fairness is maintained for members of the same class/course by avoiding preferential treatment, and so that instructors are not burdened with having to create extra quizzes, deliverables, etc. It also reflects professional practice, as failing to show up to work and missing deadlines can be very costly to the company and individual (for example: not submitting a contract proposal, or design review on time). Please read the policy here: [Link: Accommodation due to illness](#)]

**Compassionate Accommodation:** If you are facing challenges that are affecting more than one course contact the Associate Chair graduate (A.C.U.G. email: [sydeunde@uwaterloo.ca](mailto:sydeunde@uwaterloo.ca)) . They will review your case and coordinate a reasonable and fair plan in consultation with appropriate others

### **FACULTY OF ENGINEERING: MORE FINE PRINT**

Faculty of Engineering website: [[Link Academic Support and Policies](#) ].

**Academic Integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect, and responsibility. [[Check Academic Integrity website for more information. Link Office of Academic Integrity](#)].

**Discipline:** A student is expected to know what constitutes academic integrity (see link above) to avoid committing an academic offence, and to take responsibility for their actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (for example: plagiarism, cheating) or about expectations for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. Relevant documents include:

- University of Waterloo Policy 71 [[Link Policy 71 Student Discipline](#)].
- Academic Penalty Guidelines [[Link Policy 71 Penalty Guidelines](#)].
- Assessment of Unauthorized Collaboration: [[Link Assessment of Unauthorized Collaboration](#)].

**Grievance:** A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt please be certain to contact the **Associate Chair Undergraduate or Academic Advisor** who will provide further assistance. [[Link Policy 70 Petitions & Grievance](#)].

**Appeals:** A decision made, or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72 (Student Appeals) [[Link Policy 72 Student Appeals](#)].

bf Note: We are facing unusual and challenging times. The instructor reserves the right to modify course topics and/or assessments with due notice. In the event of further challenges, the instructor will work with the Department to find reasonable and fair solutions. Writing and Communication Centre.

**The Writing and Communication Centre** works with students in all Faculties to help you consider your audience, clarify your ideas, develop your voice, and write in the style appropriate to your discipline. We offer one-on-one support for writing papers, delivering presentations, integrating research, and revising for clarity and coherence. Group appointments for team-based projects, presentations, and papers are also available.

**All of our services are available virtually:** booked appointments, drop-ins, resources, and writing groups. Check out our website for other ways to interact with us, such as open online forums and online ?Question and Answers?. Visit us at [www.uwaterloo.ca/wcc](http://www.uwaterloo.ca/wcc).

Please note that communication specialists guide you to see your work as readers would. We can teach you revising skills and strategies, but will not change or correct your work for you. Please bring your assignment instructions and any notes or drafts to your appointment.

[[Link Writing and Communication Centre](#)].

AccessAbility Services (A.A.S.) is the University's centralized office for the provision of academic accommodations for students with a known or unknown disability, illness, or condition. Even if students are unsure of whether they qualify for A.A.S. support, an A.A.S. consultant can talk them through next steps, and refer them elsewhere if appropriate. [[Link AccessAbility Services](#)].

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**Fair Contingencies for Emergency Remote Teaching.** We are facing unusual and challenging times. The course outline presents the instructor's intentions for course assessments, their weights, and due dates in Winter 2022. As best as possible, we will keep to the specified assessments, weights, and dates. To provide contingency for unforeseen circumstances, the instructor reserves the right to modify course topics and/or assessments and/or weight and/or deadlines with due and fair notice to students. In the event of such challenges, the instructor will work with the Department/Faculty to find reasonable and fair solutions that respect rights and workloads of students, staff, and faculty.