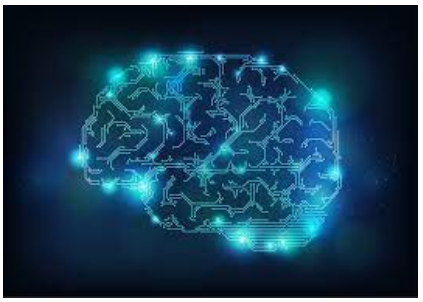
COMP 499/691: Conversational Artificial Intelligence

Background and Motivation

Building machines able to naturally converse with humans is a crucial milestone for reaching higher levels of artificial intelligence. **Conversational AI** is a relatively new terminology that includes all the technologies needed to build machines able to communicate with humans. This technology is evolving rapidly and will eventually allow humans to communicate with machines in a way that mirrors human-human interaction. Big tech companies and startups made major investments in this field and have developed systems used by millions of users worldwide, such as speech assistants (e.g., Siri, Alexa, Google Home) and large language models (e.g, Chat-GPT, Bard, Llama, Gemini, etc). According to some analysts, the global conversational AI market size was USD 6.8 billion in 2021 and will grow to USD 19.4 billion by 2027. The job market is constantly looking for highly-qualified experts, which are hard to find due to the current lack of specific training opportunities at the university level. The Montreal AI ecosystem is constantly looking for experts in Conversational AI as well. Examples of companies interested in this technology are *Nuance*, *Ubisoft*, *Fluent AI*, *Korbit*, *Descript*, *Winning minds*, *Ubenwa* and many others.

In light of the growth of this field, it is now more important than ever to form the next generation of experts in conversational AI. One challenge is that there are a large variety of technologies involved in such complex systems. For instance, conversational AI combines machine learning, speech processing, signal processing, language processing, text understanding, dialogue, and natural language processing. These components have traditionally been viewed as disconnected technologies for years, but they have been converging due to the rise of deep learning. Traditionally, these topics have been addressed in separate university courses (e.g., natural language processing, speech processing, etc). Instead, the proposed course would like to provide a unified end-to-end global view of the field that allows students to familiarize themselves with the full pipeline of modules involved in modern conversational AI systems. This is made easier by open-source toolkits like SpeechBrain (which is a popular project led by the course proposal), which significantly speed up the development of these technologies.

The course will contribute to providing students with the technical background needed to build a state-of-the-art conversational AI system. The course is aimed at both graduate students and advanced undergraduate students with a background in AI / ML. Students will progressively gain familiarity with all the technologies involved in modern systems through tutorials and lab sessions. They will also conduct a hands-on project on a real-world human-machine problem. The course adds value to the teaching portfolio of Concordia University by complementing the artificial intelligence courses, such as Machine Learning, Deep Learning, Artificial Intelligence, and Natural Language processing.

Instructor:

Mirco Ravanelli <mirco.ravanelli@concordia.ca>

Teaching assistants

Pooneh Mousavi <mousavi.pooneh@gmail.com> (Lab Instructor)
Shamanth Nayak <nayak.shamanth2000@gmail.com> (Marker)

Weekly Schedule

- *Starting date:* January, 17
- *Duration:* 12 weeks

Lectures:

- **Wednesday 5:45–8:15 pm** in H564 SGW

Labs sections:

- **Thursday 6.00 pm–8:00 pm** in H903 SGW (Pooneh Mousavi)

The course is planned to be held in person (both lectures and labs). There is no hybrid mode this year. We strongly recommend you participate in the lectures and labs.

Prerequisites

This course requires the following prerequisites:

- Prerequisite: COMP 432 (machine learning), COMP 6321 (machine learning), or permission of the instructor.

Moreover, it requires the following abilities:

- Strong Python programming skills.
- Good knowledge of linear algebra, calculus, and math in general.
- Basic Knowledge of neural networks, and deep learning.
- Basic Knowledge of PyTorch.

This course will teach you crucial topics that are highly demanded today in many jobs. However, it requires a significant amount of time and effort. Make sure you do this course only if you have enough time to spend on it.

Tentative Schedule

There will be *12 lectures* and *12 labs*. A *mid-term* exam is scheduled for **March 6**). A *final exam* is scheduled at the end of the course. Extra material (mainly recorded lectures on some specific topics) might be assigned to the students to deepen some of the topics addressed during the lectures.

A tentative week-to-week schedule is given below, but it may be subject to small changes.

Lec	Date	Lecture topics	Lab topics
1	January, 17	Introduction to Conversational AI	Exercises with PyTorch
2	January, 24	Deep Learning	Exercises with SpeechBrain
3	January, 31	Convolutional Neural Networks	CNNs
4	February, 7	RNN-based Sequence Learning	Attention Mechanisms
5	February, 14	Transformers	Transformers
6	February, 21	Speech Features	Speech Features
	March, 6	Mid-term Exam	
7	March, 13	Self-supervised Learning for Speech Processing	Self-supervised Speech Features
8	March, 20	Speech Recognition	Speech Recognition
9	Remote	Extra: Advanced Speech Recognition	Beamsearch
10	March, 27	Language Models	Spoken Language Understanding
11	April, 3	Large Language Models	Response Generation
12	April, 10	Other Conversational AI tasks	Large Language Models and Speech Synthesis
	TBD	Final Exam	

Additional Activities (Tentative Schedule)

To give students the opportunity to deepen understanding of certain topics, we plan to conduct extra classes. These sessions may be either optional or mandatory.

Exam Preparation (optional)
To assist students in preparing for the midterm and final exams, we have scheduled preparation lectures where a template exam will be discussed and solved. While attendance is not mandatory, it is highly recommended. Additionally, these sessions will be recorded to accommodate students unable to attend in person, ensuring equitable access to the preparatory material.

Week	Date	Room	Lecture topics
6	February, 23 11 am - 1 pm	Remote	Preparation for the midterm exam
11	April, 17 2 pm - 4 pm	Remote	Preparation for the final exam

Extra Lecture (mandatory)
The instructor will provide supplementary pre-recorded lectures to dive deeper into topics not covered in the main lecture due to time constraints. Attendance is mandatory, and the content will be included in the exams. The tentative list of extra lecture is the following (other lectures can be added if required):

Week	Room	Lecture topics	Note
8	Remote (pre-recorded)	Advanced Speech Recognition	There is a mandatory lab assignment associated with this lecture.

Extra Lecture (optional)
As an additional offering, we intend to arrange optional lectures this year on advanced machine learning topics, specifically focusing on machine learning for EEG signal processing. Dr. Davide Borra from the University of Bologna will be conducting these sessions. While participation is not obligatory, we highly encourage students to take advantage of this additional learning opportunity.

Date	Room	Lecture topics
Feb., 16 9 am - 11 am	Remote	Introduction to EEG and EEG decoding
Feb., 23 9 am - 11 am	Remote	EEG Decoding with SpeechBrain

March, 15 9 am - 11 am	Remote	Decoding speech from the EEG

Textbook

You don't need a textbook for this course. The slides, tutorials, and labs will be enough. Here is a list of textbooks that might be useful along the way:

- *Pattern Recognition and Machine Learning by Christopher M. Bishop (2006)*
- Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville (2016)
- *Spoken Language Understanding*: Systems for Extracting Semantic Information from Speech by G. Tur, and R. De Mori (2011).
- *Conversational AI: Dialogue Systems, Conversational Agents, and Chatbots Paperback* by M. McTear (2020).
- *Spoken Language Processing: A Guide to Theory, Algorithm and System Development Hardcover* by X. Huang, A. Acero, Hsiao-Wuen Hon. (2001).

Additional reading materials, such as scientific articles, blog posts, and videos will be suggested at the end of each lecture.

Course evaluation

Each student will be evaluated based on the following grading scheme.

- 30% Project
- 30% Midterm Exam
- 30% Final Exam
- 10% Lab Assignment (1% each, best 10 of 12)

Note: Participation in the mentioned optional seminar can earn you up to 4 additional points.

Lectures

The lectures will be held in person (no hybrid modality). The slides will be made available to the students through the course Moodle page right before the lecture. Participating in the lectures is strongly encouraged. In particular, students are encouraged to actively participate in the lecture by asking questions, sharing doubts, requests for clarification, etc. The slides are done with google slides. This allows students to comment on them and ask questions on specific parts. Each lecture lasts 2 hours and 30 minutes. After each section, one or more short breaks (e.g, 10 minutes) will be done. To ensure ample time, please allocate a 3-hour slot for the lecture. Some sessions may extend slightly, particularly when there are numerous questions and interactions with the students.

Labs

The lab sessions will be held in person as well. Students are strongly encouraged to attend labs carefully. The topics addressed during the labs can be objects of question in the mid-term and final exams. Labs are a major learning opportunity in this course, in terms of practical skills and understanding how the algorithms work. During the lab section, the

instructor will typically do some practical tutorials on the week's topic. Then, the instructor will introduce the lab assignment of the week. The lab will be made available at the beginning of the week. You are thus encouraged to start solving the lab even before your lab session. This way you can take advantage of the lab session to ask clarification questions to the TA. Note that the lab assignment will require some hours to be solved and cannot be completed during the lab session (you will likely need to conclude this at home). You have until the end of the week to submit the final lab assignment in Moodle. We will do our best to grade the lab as soon as possible to provide feedback to the students. For this reason, we cannot grant any extensions to the deadlines. There are 12 labs worth 1% each up to a maximum of 10% of the total grade. This means that you can skip two labs without any score penalization.

Notes:

- You must attend your assigned lab section ONLY. Please respect this rule, it helps balance work among the TAs and keeps them organized.
- Students are encouraged to help each other with labs verbally, but copying code is forbidden. You must be the author of all your submitted answers. Violations will be reported.
- You have to submit the lab assignment according to the deadline specified by the instructor. Extensions cannot be granted. Late submissions will not be graded.

Further details are available in the *Lab guidelines* on Moodle.

Projects

The project is an important part of the machine learning course. The goal of it is to show that you gained familiarity with the conversational AI techniques explained during the lecture and labs and that you can implement an actual model. The project grade counts as 30% of the final grade.

The instructor will make available some project proposals in the first weeks of the course. As an alternative, students are welcome to propose a project. In this case, the students have to write a project proposal (max two pages) and submit it before **February 16 11.59 pm** (the deadline for a project proposal). The instructor will review it and must explicitly approve it (on Moodle). The instructor might ask you to fine-tune the proposal (or write another proposal) if the project does not meet the expectations (e.g, the project is too similar to one of the labs, the project is unfeasible with the current time and computation constraints, the proposal is not clear, etc).

Each student must work on a different project. The project must be individual work done by the student (no group projects). Students are welcome to meet, exchange opinions, and suggestions, share issues, etc when working on their projects. However, the project must be the individual work of the students. Every violation will be reported. Each student will be assigned to a project advisor. The project advisor will monitor the evolution of the project and provide some suggestions along the way. Nevertheless, the project advisor is not supposed to solve the problem or debug the code for you.

Further details are available in the *Project guidelines* on Moodle.

Exams

We plan to do a mid-term exam on **March 6** (5:45–8:15 pm EDT) that will focus on the topics of the first 6 lectures and labs. A final exam will be done at the end of the course (the exact day will be posted when available) on the topics addressed in the last 6 lectures (5 lectures + 1 extra lecture) and labs. The exams will be quizzes composed of different questions (ranging from simple to more challenging ones). You will have 2 hours and 30 minutes to complete it.

The exams will be done in person. In this case, it is your responsibility to be able to start the exam on time and not be late. Calculators approved by Concordia can be used.

Communication

Most of the communication can be managed through emails. Depending on the specific request, please send an email to the following people:

Questions about the Lectures	Send an email to the main instructor. *The object must start with "COMP 499/691 Lecture"*
Questions about Labs	Send an email to your lab instructor. *The object must start with "COMP 499/691"* *(If needed, add the link to your lab submission).*
Questions about Projects	Send an email to your project advisor. *The object must start with "COMP 499/691 Project"*
Questions about Labs grades	Send an email to the marker. *The object must start with "COMP 499/691 Lab Grade"*
Questions about Exam grades	Send an email to the main instructor. *The object must start with "COMP 499/691 Exam Grade"*
Other Requests	Send an email to the main instructor.

Please, cc the main instructor in all the emails. Make sure the object contains the required keywords (this helps us stay organized). The teaching team will try to reply as soon as possible. The team will be happy to help you. However, we normally receive a high volume of emails and we kindly ask students to send us emails for important issues or requests.

If you think the issue cannot be solved by email, you can book an appointment during office hours. Each week the teaching team has a few hours to dedicate to that. The students will be able to book up to one 15-minute meeting. To book the meeting just send an email to the instructors. Please, make sure to show up in time if you book an appointment (otherwise you will miss the window). We have limited slots every week. The students will be served based on the reservation date. Make sure you use the time slot assigned to you to discuss important issues only. The following is a tentative schedule for **office hours**:

Mirco Ravanelli	Wednesday, 4 pm - 5 pm (in-person)

Pooneh Mousavi	Thursday 5 pm - 6 pm (remote)
Shamanth Nayak	Thursday 4 pm - 5 pm (remote)

Course content

Lecture slides and lab files will be hosted on Moodle and posted on a weekly basis.

Important Dates

February, 16 (11.59 pm)	Deadline for Project Proposals (if any)
March, 6	Mid-Term Exam
April, 21 (11.59 pm)	Deadline for Project Submissions
TBD	Final Exam

Academic integrity

The instructor takes academic integrity extremely seriously. Students who are suspected violating the Code of Conduct will be reported. An official procedure, that might lead to major sanctions for the students, will start.
This includes plagiarism of code and/or written text, attempted communication during the exams, and everything else in the list of offenses reported in the Code of Conduct.

All submitted materials must be authored by you alone. At no time should you offer, ask for, or be in possession of, another student's solution to any graded component of this course. Please, if you are struggling, do not cheat yourself out of an opportunity to learn, or cheat your fellow students out of a fair assessment, or risk ruining your academic standing. Instead, ask for help from TAs or the instructor right away, because we sincerely want you to learn and want you to succeed!