

COM S 6720: Advanced Topics in Artificial Intelligence — Understanding Intelligence

Iowa State University

Spring 2025

Class meet: Wed 1:10–3:40 pm @ Kildee 0105

Instructor: Wei Le (weile@iastate.edu: please preface all email subjects with “6720: ”)

Office Hours: Tue 3:00-4:00pm, Wed 10:30-11:30am @ Atanasoff 210

TA: Carter Wunsch (cwunsch@iastate.edu)

Office Hours: Thur 11:00 am @ Pearson 0112

Homework assignments, submission, and grades as well as lecture notes: Canvas

1 Course Description

In this 600-level seminar course, we will read, learn, ponder and discuss the topics of *artificial intelligence*. We will reflect on the fundamental concepts related to *intelligence* and teach the state-of-the-art, representative *artificial intelligence* algorithms, techniques, and tools. We will discuss the research methods that are useful for this fast evolving field and share our thoughts about the future of artificial intelligence and how our work and life will be reshaped. I designed the course with the goals of providing you resources of learning, guiding your intuition, and promoting your imaginative thinking towards promising artificial intelligence research.

The topics of the course include (tentative as time permits):

- Fundamental thinking about intelligence: What is intelligence? What are intelligent behaviors? What are the cognitive functions that enable intelligent behaviors? What is a thought? Can thoughts exist without languages? What is a world model?
- The inspirations of natural intelligence for artificial intelligence
- Reasoning (including planning)
- Perception and Representation Learning
- Knowledge: Representation and Retrieval
- Agents
- Collective Intelligence and Social Interactions
- Memory and Retrieval
- LLM alignment

- Intelligence in Games
- Future of Artificial Intelligence
- Interesting Topics Related to Intelligence: Neuroscience, Psychology, Game Theory ...

The objectives of the course are to help you:

1. develop a deeper understanding on intelligence and artificial intelligence
2. gain an overview of the state-of-the-art artificial intelligence research,
3. improve your teaching and critical thinking skills in artificial intelligence, and
4. establish a foundation of future artificial intelligence research

How I run the class: Each class will consist of three sections. First, we will present and discuss "this week's AI research and news" (around 20-30 minutes); second, we will have a lecture/presentation to teach the topic based on the paper(s) and the text book chapters (around 60-75 minutes); finally, we will have Q&A and discussions lead by the instructor and students.

2 Textbooks and Resources

The course does not require a text book. Our classes and learning materials will be based on papers, guest lectures, online talks, and also the book "A Brief History of Intelligence" by Max Bennett. The instructor will assign readings weekly.

3 Tentative Schedule

The following is a tentative schedule. Please use the course announcement on Canvas to proceed your reading assignment.

Week 1 (Jan 22):

- No class. The instructor will be out of town. We will catch up the hours in Week 8 after the spring break.
- **Homework:** Reasoning with Large Language Models, a Survey (Sections 1, 2 and 5)

Week 2 (Jan 29): LLM

- LLM reasoning, lecture by Carter Wunsch
- Pure imagination: Innovative with Generative AI, Today and Tomorrow, guest lecture by Bell Tyler
- **Homework:** Large language models for artificial general intelligence (AGI): A survey of foundational principles and approaches

Week 3 (Feb 5): AGI

- Syllabus
- AGI, Natural and Artificial Intelligence, lecture by Wei Le
- Discussion: LLM reasoning, LLM for AGI
- **Homework:**

- Presentation and project team sign-up
- CivRealm: A Learning and Reasoning Odyssey in Civilization for Decision-Making Agents

Week 4 (Feb 12): Intelligence in Games

- This week's AI
- Intelligence in Games, presentation (by Hengbo Tong) and discussion,
- **Homework:** Navigation World Models

Week 5 (Feb 19): World Model

- Diffusion Model: guest lecture by Qi
- Navigation World Models: presentation and discussion
- **Homework:** Video Representation Learning with Joint-Embedding Predictive Architectures

Week 6 (Feb 26): Representation Learning

- This week's AI
- Video Representation Learning: presentation and discussion
- **Homework:** AutoCodeRover: Autonomous Program Improvement

Week 7 (Mar 5): Agents

- This week's AI
- Agents in SE: presentation and discussions
- **Homework:** TravelPlanner: A Benchmark for Real-World Planning with Language Agents

Week 8 (Mar 12): Planning

- This week's AI
- LLM planning: presentation and discussions
- **Homework:**
 - Project mid-term presentation
 - Scallop: From Probabilistic Deductive Databases to Scalable Differentiable Reasoning

Week 9 (Mar 26): Mid-term project presentation and mentoring

Week 9 (Mar 28) (makeup class for week 1): Mid-term project presentation and mentoring

Week 10 (Apr 2): Neural Symbolic Framework

Week 11 (Apr 9): Knowledge Representation: from Past to Future

Week 12 (Apr 16): Memory and Retrieval

Week 13 (Apr 23): Collective Intelligence and Social Interactions

Week 14 (Apr 30): Future AI and other topics, e.g., Game Theory, Psychology or Neuroscience

Week 15 (May 7): Final project presentation

Week 16 (May 14): Final report due

Considering the rapid advance of the AI research, we will announce the papers for the second semester later. Students are welcomed to suggest alternative papers for the topic.

4 Course Work and Evaluation

1. Weekly AI paper reading report (36%): student submits a few slides of *thoughts for discussion* and the instructor will sample students to present during class.

The slides should include the following sections. Please keep your points concise.

- The strength of the paper
- The weakness of the paper
- The novelty of the paper
- The impact/research contributions of the paper
- Future research ideas
- Questions for discussions

We will grade your reading report based on the quality of the ideas and clarity of the writing, we will provide a grade of A (100%); B (80%); C (60%).

2. Contribution to the class discussions and learning (10%): in the 600 level seminar class, graduate students are encouraged to participate in discussions, ask and answer questions, and create a collaborative learning environment. You are welcomed to bring in additional relevant papers and bring in key points from your research background.

Grading: A (100%)—active participation with great comments and questions; B (80%)—some comments and questions; C (60%)—attend the class with minimum participation; D (< 60%) did not attend class often.

3. This week's AI (3%): AI advances rapidly. A great way to learn the SOTA AI is to read daily or at least weekly on the most recent AI papers and news. We will teach how to find these papers. In each class, students will share any AI highlights of the week (5-10 minute presentation per person). Each student will do one presentation per semester.

4. Team presentation on a selected research topic (45-60 min presentation time) (15%)

Grading: We will grade the presentation based on whether you thoroughly cover the key knowledge and background of the paper, and whether you have provided a good structure of the presentation and clearly conveyed your points.

5. Final Project (36%)

- Midterm progress: (1) the research idea and an example that can explain the idea, (2) related work and the novelty of the idea, (3) plan for implementation and experiments, e.g., listing tools, benchmarks, baselines, research questions
- Final submission: 6-page research paper

Grading:

- Overall research quality: (1) the novelty of the research ideas (2) the soundness of the research and experiment methods (3) the impact of the overall work
- Report: clarity, completeness
- Presentation (including demo): clarity, completeness
- Artifact evaluation: reproducibility, correctness

Submission:

- Weekly reading report is due Friday 11:59 pm on Canvas. You can still submit your homework after the deadline until TA starts to grade the homework (watch out the TA's announcement on Canvas on when the grading starts). Any submissions after that will not be graded.
- For your other presentations such as "this Week's AI" and your project presentation, please upload your slides before the class.

5 Academic Integrity

You are encouraged to discuss and share your views on papers and final projects. You are welcomed to answer any appropriate questions from your classmates and help each other with debugging. But you should not directly copy presentation slides or code from your classmates or from the Internet without a citation.

Iowa State University's policy on academic dishonesty: Suspected academic misconduct will be reported to the dean of students office <http://www.dso.iastate.edu/ja/academic/misconduct.html>

6 Accommodations for Disabilities

We would like to hear from you if you have a disability that may require some modification of seating, testing, or other class requirements. If so, please request that the Disability Resources staff send a Student Academic Accommodation Notification form verifying your disability and specifying the accommodation you will need. Then bring the Accommodation Notification form along and talk to the instructor as soon as possible so appropriate arrangements may be made.

7 Free Expression

Iowa State University supports and upholds the First Amendment protection of freedom of speech and the principle of academic freedom in order to foster a learning environment where open inquiry and the vigorous debate of a diversity of ideas are encouraged. Students will not be penalized for the content or viewpoints of their speech as long as student expression in a class context is germane to the subject matter of the class and conveyed in an appropriate manner.