Course Syllabus
CS7637-O: Knowledge-Based AI: Cognitive Systems (OMS)
Spring 2015

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Course Description:
This is a core course in artificial intelligence. It is designed to be a challenging course, involving significant independent work, readings, assignments, and projects. It covers structured knowledge representations, as well as knowledge-based methods of problem solving, planning, decision-making, and learning.

Competency:
To succeed in this course, you should be able to answer 'Yes' to the following six questions:

1. Are you confident with computer programming?
2. Are you familiar with basic concepts of data structures and object-oriented programming, such as inheritance and polymorphism?
3. Are you familiar with basic concepts of algorithm design, such as algorithms for sorting, searching, and matching?
4. Are you confident with either Java or Python?
5. Are you comfortable writing a 1000-word essay/design report in English each week?
6. Are you comfortable completing a large, challenging design/programming/analysis project every three weeks or so.

If your answer is a “No” to any of these questions, this course may not be appropriate for you.

Learning Goals:
The class is organized around three primary learning goals. First, this class teaches the concepts, methods, and prominent issues in knowledge-based artificial intelligence. Second, it teaches the specific skills and abilities needed to apply those concepts to the design of knowledge-based AI agents. Third, it teaches the relationship between knowledge-based artificial intelligence and the study of human cognition.

Learning Strategies:
This structure of this course is determined by several pedagogical motivations:

- First, this class is taught through learning by example. Each topic is taught through examples of the way in which humans and artificial intelligence agents approach certain problems, often building from human thought toward AI agents and subsequently referring back to human cognition.
- Second, each topic is also taught through learning by doing; you will participate in the reasoning within each particular lesson, and subsequently tie the topic back to a broader problem.
- Third, the learning in this class is project-based. This class has four projects, each of which build on the previous one, and the application of the lessons to the design of KBAI agents is directed through these projects.
- The fourth pedagogical motivation in this course is personalization. Individualized feedback will be given on your performance on the exercises, assignments, projects, and tests. Additionally, you are welcome and encouraged to proceed at your own pace throughout the lessons, including viewing them outside of the designed order to better align with your interests.
- The fifth pedagogical motivation is collaboration. We will form small “study groups” of all the students in the course. While the tests, the projects and the assignments in the course require individual work, we will encourage the study groups to work together on all aspects of the course (including discussions about the projects and the exercises).
- Finally, we will encourage reflection. At the conclusion of each lesson, we ask each student to reflect on what they learned in the class. Each design project requires the writing of a design report that explains and critiques, and reflects on the student’s work on the project.

Learning Outcomes:
At the conclusion of this class, you will be able to accomplish three primary tasks. First, you will be able to design and implement a knowledge-based artificial intelligence agent that can address a complex task using the methods discussed in the course. Second, you will be able to use this agent to reflect on the process of human cognition. Third, you will be able to use both these practices to address practical problems in multiple domains.

Learning Assessments:
For your grade in this class, you will complete the following:

- About 25 activities (Introductions in Week 1, Peer Feedback on 8 assignments, Four surveys, Discussions of weekly required readings)
- 5 written assignments
- 4 projects
- 2 exams

KBAI Lessons:
The course is broken into 26 lessons. Although the length of individual lessons will vary, students are encouraged to complete approximately two lessons per week. The times in parentheses below reflect the estimated amount of time each lesson will take to complete, including all videos and exercises. Suggested dates are listed with the official course calendar.

Lesson Number	Lesson Topic	Approximate Length of Video in Minutes	Required Reading
1	Introduction to the Course	45	
2	Introduction to Knowledge-Based Artificial Intelligence	60	Russell & Norvig Chapter 1, Section 1
3	Semantic Networks	60	Winston, Chapter 2, pages 16-32
4	Generate & Test	30	Winston, Chapter 3, pages 47-50
5	Means-Ends Analysis & Problem Reduction	60	Winston, Chapter 3, pages 50-60
6	Production Systems	60	Winston Chapter 7, pages 119-137 Winston Chapter 8, 163-171
7	Frames	45	Winston Chapter 9, pages 179-182, 202-206
8	Learning by Recording Cases	30	Winston Chapter 19
9	Case-Based Reasoning	60	Kolodner, Introduction to Case-Based Reading
10	Incremental Concept Learning	60	Winston Chapter 16, pages 349-358
11	Classification	45	Stefik, Chapter 7, Parts 1 and 2
12	Logic	90	Winston Chapter 13
13	Planning	75	Winston Chapter 15, pages 323-336; Russell & Norvig Chapter 11, Section 3
14	Understanding	30	Winston Chapter 10, pages 209-220
15	Commonsense Reasoning	60	Winston Chapter 10, pages 221-228
16	Scripts	30	Schank & Abelson, Scripts, Plans and Knowledge
17	Explanation-Based Learning	45	Winston Chapter 17
18	Analogical Reasoning	60	
19	Version Spaces	60	Winston Chapter 20
20	Constraint Propagation	45	Winston Chapter 12, pages 249-266
21	Configuration	45	Stefik, Chapter 8 Parts 1 and 2
22	Diagnosis	45	Stefik, Chaper 9
23	Learning by Correcting Mistakes	45	Winston Chapter 18
24	Meta-Reasoning	30	
25	Advanced Topics	60	
26	Course Wrap-Up	30	

We describe the readings below. You will notice that the times given here add up to approximately 22 hours of material. The in-person class meets for approximately 44 hours per semester. This means that approximately one-third to one-half of the time in the in-person class is spent on class discussions. Similarly, you should expect to spend a few hours a week interacting on the forums with your study groups and classmates.

Required, Recommended, & Optional Readings:
This course is reading extensive, with several kinds of readings. Firstly, for most lessons, there is a primary reading. The primary reading for each lesson is **required** reading. It will typically comprise of parts of chapters from one of three books:
Artificial Intelligence. Patrick Winston. Third Edition. MIT Press 1993.
Knowledge Systems. Mark Stefik. Morgan-Kaufmann. 1995.
Artificial Intelligence. Stuart Russell and Peter Novig. Third Edition. Prentice-Hall. 2010.

The first of these three books (Winston) is available online at (http://courses.csail.mit.edu/6.034f/ai3/rest.pdf).
When needed, we will upload required readings from the other two books into T-Square. So you need **not** buy any textbook for this class. In preparing the midterm and final examinations, we will assume knowledge of the required readings and thus so we strongly recommend keeping up to date with them as the semester goes along.

Secondly, for most lessons, there will be a small set of secondary readings. These secondary readings are composed of scientific articles that go into more depth than the videos or the primary readings. These secondary readings are **optional**. You will not need them for preparing for the midterm and the final examinations. However, you are welcome to pursue them at your leisure for any lesson that may especially interest you.

Thirdly, we will have a weekly reading for discussion on the Piazza forum for the class. On the Friday of each week, we will have a Piazza discussion on the reading for that week. The readings will be of more general nature than specific topics or lessons. Some of them will relate KBAI to work, life, society and the world. These readings are **highly recommended.** Although the midterm and final examinations will not ask any questions based on these readings, you will need them to participate in the Piazza discussions in an informed manner.

While the primary/required readings are shown above, we will put the recommended and optional readings on the class wiki on T square.

Course Schedule:
Below is the recommended course schedule for CS7637. Although you are free to watch the lessons in any order you choose and at any pace, this is a minimal pace for moving through the lessons. Note additionally that for the midterm examination, you will be responsible for all material through the lesson on Planning. For the final exam, you will be responsible for all material in the course.

All assignments, projects, and examinations are due each week on Sunday. The 'Assignment' column here gives which exact assignment is due each week. The 'Assignment Due' column gives the date on which that assignment is due. All assignments are due at midnight AoE (anywhere on earth, GMT/UTC-12). Make sure to set your time zone in T-Square to see due times in your local time.

Week	Week of...	Lessons	Assignment	Assignment Due	Notes
1	January 05	Introduction to Knowledge-Based AI, Introduction to CS7637	Student Introductions on Piazza & Initial Course Survey	January 11	Initial Course Survey
2	January 12	Semantic Networks, Generate & Test	Assignment 1	January 18	Study groups formed
3	January 19	Means-Ends Analysis, Production Systems	Assignment 2; Peer Feedback on Assignment 1	January 25	Jan. 19 is Georgia Tech MLK holiday.
4	January 26	Frames	Project 1; Peer Feedback on Assignment 2	February 01	
5	February 02	Learning by Recording Cases, Case-Based Reasoning	Assignment 3	February 08	
6	February 09	Incremental Concept Learning, Classification	Assignment 4; Peer Feedback on Assignment 3	February 15	
7	February 16	Logic, Planning	Project 2; Peer Feedback on Assignment 4	February 22	
8	February 23	Understanding	Mid-Term Examination	March 01	
9	March 02	Common Sense Reasoning,	Assignment 5	March 08	

		Scripts			
10	March 09	Explanation-Based Learning, Analogical Reasoning	Assignment 6; Peer Feedback on Assignment 5	March 15	Mid-Course Survey
11	March 16	Version Spaces, Constraint Propagation	Project 3; Peer Feedback on Assignment 6	March 22	March 16-20 is Georgia Tech Campus Spring Break
12	March 23	Configuration	Assignment 7	March 29	
13	March 30	Diagnosis, Learning by Correcting Mistakes	Assignment 8; Peer Feedback on Assignment 7	April 05	
14	April 06	Meta-Reasoning	Project 4; Peer Feedback on Assignment 8	April 12	
15	April 13	Advanced Topics, Wrap-Up	Final Exam	April 19	
16	April 20			April 26	Course and Instructor Opinion Survey (CIOS)
17	April 27			May 03	End of Course Survey

Course Communication:
Any new class information (such as changing due dates, requirements, etc.) that you are responsible for knowing will be sent out in two ways:

- A T-Square announcement with an email notification.
- A pinned Piazza announcement in the 'announcements' folder with an email notification.

Thus, any information you are required to know will arrive in your email inbox at least twice, as well as be available on the course's T-Square and Piazza pages.

If we have any questions regarding your assignments, projects, or exams, we will email you. This is especially important in the event that your project code does not work when initially turned in. Georgia Tech classes typically stipulate that you are asked to check your email at least once every 24 hours on weekdays. While there will not likely be anything in this course that requires an answer that fast, we do ask that you check your email with that level of regularity in case something comes up with one of your submissions. If we contact you and don't hear back within that time frame, your grade may be affected (and we dont want that).

Office Hours:
In general, if you have a question about the course contents, the projects, the assignments or the examinations, we ask that you first ask them on Piazza so that everyone in the class can see the questions and the answers. In addition, however, we offer two kinds of office hours to answer the kinds of questions that are difficult to answer in text: synchronous and asynchronous.
Synchronous office hours will be run via a Webex teleconference by David and/or Sridevi. The specific time of synchronous office hours will be announced after the initial survey to find the ideal time. During office hours, you can access the teleconference at this link: https://gatech.webex.com/gatech/e.php?MTID=mf8f80e9a5465de2e0f30cfda8ec03925

Clicking that link should allow you to set up Webex and participate in the teleconference. If you have any difficulty, please email the TAs and let us know. Note that generally, these office hours will **not** be recorded. Synchronous office hours are intended for conversations about individual projects, discussions about course material, etc. rather than straightforward question-and-answer; because they are more personal to the individual attendees, they are not as useful when recorded and posted. If anything comes up in these office hours that is relevant to the rest of the class, it will be recorded or posted on Piazza. In the event that synchronous office hours are not offered during a time that you can make, let us know and we'll try to schedule a 1:1 session with you (time permitting).

Asynchronous office hours, on the other hand, **will** be recorded. Asychronous office hours will be recorded by Ashok and posted each week if there are sufficient questions to have an office hours video. To post a question for Ashok to answer, post to the office_hours folder on Piazza.

If your question is about a private issue, such as a grade on an examination, you may post a private Piazza message (visible only to instructors) or send an email to the instructors (ashok.goel@cc.gatech.edu; david.joyner@gatech.edu) or the TA (sridevi@gatech.edu). Please remember, however, that the instructors and TA are together responsible for a class of over 200 students in addition to in-person classes and other responsibilities, so please be patient in awaiting responses and, whenever possible, post your questions on the forum first.

Grading:

Grades will be based on four types of assessments according to the following percentages:

- Four Projects: 50%
- Five assignments: 15%
- Midterm Examination: 10%
- Final Examination: 20%
- Class activities (such as Peer Feedback and discussion of required readings): 5%

Grades will be normalized at the conclusion of the class. This is designed to allow lots of room for the identification of improvement, mastery, and excellence even after a satisfactory grade has been achieved. As such, many of the assignments, projects, and exams will be graded on a scale where the average looks very low; the average on Project 1 last semester, for example, was a 33 out of 50. This, of course, doesn't mean half the students failed the project, it just means the project scoring doesn't map to the traditional "90% = A" distribution. We'll post statistics on the class median and distribution with the assignments so you can get a gauge for how your scores map to the overall class. Although we understand the importance of grades, we encourage you to focus first on doing the best you can on all assignments; if you do, your grade should take care of itself.

Projects:
This course will consist of four design and programming projects, each of which will build on the previous one. In all four projects, you will design and implement an artificial intelligence agent that solves problems on a human intelligence test. You will have approximately three weeks to work on each project, and the results of each will be directly applicable to the next. Agents may be programmed in Java or Python.

The projects are due at GMT/UTC−12:00 hour or midnight in the International Date Line West (IDLW) time zone on the following due dates; make sure to set your time zone in T-Square to see due times in your local time:

- Project 1: February 1
- Project 2: February 22
- Project 3: March 22
- Project 4: April 12

At the conclusion of each project, the five best projects will be selected and, with the students' permission, posted for public viewing. The selection of the five "best" will be made in large part based on how many problems each student's agent gets correct, but it may also be based partially on evaluation of the program design and documentation by the graders. If a particular project takes an especially creative design approach or has an especially deep design report, for example, it may be selected as an exemplary project even if other projects technically performed better.

Please note that projects are due on Sundays because past reports have indicated many OMS students work on class work on weekends; we have thus moved projects to being due at the end of the weekend instead of on Fridays. However, typically the professors, TAs, and graders will not be as available to answer questions on the weekends, so we urge you to work ahead and post or ask any questions that arise well in advance of the project deadline.

Assignments:
To complement these design and programming projects, all students will also complete five short written assignments. Early in the semester, these assignments will help build toward the programming projects. Later in the semester, these assignments will help connect the class material to bigger problems, or connect the class material to your own work or life experience.

Eight written assignments will be given; you are required to complete **five** of them. Specifically, you **must** complete Assignments 1 and 2, and you **must** choose 3 assignments from assignments 3 through 8 to complete. In other words, you must do the first two assignments, and you may skip three of the last six assignments.

- Assignment 1: January 18
- Assignment 2: January 25
- Assignment 3: February 8
- Assignment 4: February 15
- Assignment 5: March 8
- Assignment 6: March 15
- Assignment 7: March 29
- Assignment 8: April 5

Assignments are due at midnight AoE (anywhere on earth, equivalent to midnight at GMT/UTC-12) for the dates given. Although assignments are due at the end of the weekend, the professor, TAs, and graders will typically not be as available on the weekends, so please ask any questions in advance.

Examinations:
Two take-home examinations will be given, a midterm and a final exam. Both examinations will be open-book and open-note. You will have approximately five days to complete each. The midterm and final examination will focus on topics in the course that are less likely to directly connect to the projects; these topics will be more explicitly articulated closer to the examinations.

The midterm will be provided on February 23, and is due on March 1st. The final exam will be provided on April 13, and is due on April 19.

Late Work:
Because of the size (>200 students) and distribution (global) of this class, we are unfortunately unable to accept **any** late work. All assignments must be submitted by the posted deadlines. If you have technical difficulties submitting the assignment to T-Square, email the TAs **immediately** and attach your (time-stamped) assignment.

If you have an emergency and absolutely cannot submit an assignment by the posted deadlines, we ask you to go through the Dean of Students' office regarding class absences. The Dean of Students is equipped to address emergencies that we lack the resources to address. Additionally, the Dean of Students office can coordinate with you and alert all your classes together instead of requiring you to contact each professor individually. You may find information on contacting the Dean of Students with regard to personal emergencies here: http://www.deanofstudents.gatech.edu/content/25/absences

Collaboration:
In general, we strongly encourage collaboration in this class. You are encouraged to discuss the course material, the exercises, the written assignments, and the projects with your classmates, both before and after assignments and projects are due. Similarly, we will be posting the best projects for public viewing so you may learn from the success of others' designs.

However, in collaborating, we draw the line at the following:

- You may **not** copy any code directly from anyone else. Again, you may use others' ideas to inform your own designs, but your project must be your own work.
- You may **not** directly copy any text from anyone else's written assignments. This includes directly paraphrasing. Again, you may use others' ideas to inform your own writing, but your assignments must be your own work.
- You may **not** collaborate at all on the midterm or final. Do not discuss the questions and answers with your classmates until after the tests are due.

Any instances of violation of this policy will be referred to the Dean of Students. If you are unsure of whether a certain type of collaboration is acceptable, please ask first, preferably on Piazza. The Georgia Tech honor code is available at http://www.catalog.gatech.edu/rules/18b.php - we recommend that you take a look.

Study Groups:
By the end of the second week, all students will be assigned to small study groups. Study groups serve a number of purposes. First, these groups are intended to give you a small, captive audience for questions and discussion. You are encouraged to ask questions of your study group by using your group's private area on Piazza. Second, as part of your written assignments, you will be asked to give your classmates feedback on their written assignments. This will be coordinated within your study groups as well.

Feedback:
Every semester is a learning experience for us as we administer this course. Thus, a lot of the instruction design in this course has changed since the last semester. There are bound to be things we can (and will) improve. First, we ask that you be patient and understanding with anything that might go wrong; we promise that we, too, will be fair and understanding, especially with anything that might impact your grade or performance in the class. Second, we ask you to give us feedback on anything that we could be doing better, as well as feedback on anything you are particularly enjoying. You may take advantage of the suggestion box on Piazza (or email the instructors and TAs).