



GRADUATE AI

LECTURE 1: INTRO

TEACHERS:

MARTIAL HEBERT

ARIEL PROCACCIA (THIS TIME)

COURSE WEBSITE

- <http://www.cs.cmu.edu/~15780>

Overview | Lectures | Homework | Project | Misc

GRAD AI

15-780: Graduate Artificial Intelligence, Spring 2012

Overview

What?

This course is targeted at graduate students who need to learn about current-day research, and about how to perform current-day research, in Artificial Intelligence—the discipline of designing intelligent decision-making machines.

Students entering the class should have a pre-existing working knowledge of linear algebra, calculus, algorithms and data structures, and basic knowledge of computational complexity though the class has been designed to allow students with a strong numerate background to catch up and fully participate. Students should also be able to program in C, C++, Java, Python, or Ruby.

The course textbook is *Artificial Intelligence: A Modern Approach*, 3rd edition, by Russell and Norvig. This is not a required purchase. We will supplement readings in this book with timely research papers posted to the course website.

Who?

The course is taught by professors Martial Hebert (RI) and Ariel Procaccia (CSD). The teaching assistant is John Dickerson (CSD). The course is open to graduate students in the School of Computer Science; interested and qualified undergraduates and other students should contact the professors for permission to join.

Schedule						
Date	Room	Lecture Title	Lecturer	Link	Notes	Search:
1/16/2012	—	—	—	—	—	No class (MLK Day)
1/18/2012	GHC 4215	Introduction	Procaccia	■	—	
1/23/2012	GHC 4215	Probabilistic inference & graphical models	Hebert	■	—	
1/25/2012	GHC 4215	Probabilistic inference & graphical models	Hebert	■	HW #1 out	
1/30/2012	GHC 4215	Probabilistic inference & graphical models	Hebert	■	—	
2/2/2012	GHC 4215	Probabilistic inference & graphical models	Hebert	■	—	
2/6/2012	GHC 4215	MDPs	Veloso	■	—	
2/8/2012	GHC 4215	MDPs	Veloso	■	HW #1 due	
2/13/2012	GHC 4215	Informed search	Procaccia	■	HW #2 out	
2/15/2012	GHC 4215	Classical planning	Procaccia	■	—	
2/20/2012	GHC 4215	Classical planning	Procaccia	■	—	
2/22/2012	GHC 4215	Motion planning	Hebert	■	—	
2/27/2012	GHC 4215	Motion planning	Hebert	■	HW #2 due	
2/29/2012	GHC 4215	Motion planning	Hebert	■	HW #3 out	
3/5/2012	GHC 4215	Constraint satisfaction problems (CSPs)	Procaccia	■	—	
3/7/2012	GHC 4215	Constraint satisfaction problems (CSPs)	Procaccia	■	—	
3/12/2012	—	—	—	—	—	Spring break!
3/14/2012	—	—	—	—	—	Spring break!
3/19/2012	GHC 4215	Constraint satisfaction problems (CSPs)	Procaccia	■	HW #3 due	
3/21/2012	GHC 4215	Perception	Hebert	■	HW #4 out	
3/26/2012	GHC 4215	Perception	Hebert	■	—	
3/28/2012	GHC 4215	Perception	Hebert	■	—	
4/2/2012	GHC 4215	Midterm exam	—	—	—	
4/4/2012	GHC 4215	MAS, game theory, social choice	Procaccia	■	HW #4 due	
4/9/2012	GHC 4215	MAS, game theory, social choice	Procaccia	■	HW #5 out	
4/11/2012	GHC 4215	MAS, game theory, social choice	Procaccia	■	—	
4/16/2012	GHC 4215	MAS, game theory, social choice	Procaccia	■	—	
4/18/2012	GHC 4215	MAS, game theory, social choice	Procaccia	■	—	
4/23/2012	GHC 4215	TBA	Hebert	■	HW #5 due	
4/25/2012	GHC 4215	TBA	Hebert	■	—	
4/29/2012	GHC 4215	Project presentations	—	—	—	
5/2/2012	GHC 4215	Project presentations	—	—	—	

Showing 1 to 32 of 32 entries

BUREAUCRACY

- TAs: John Dickerson and Felipe Trevizan
- Useful but not required book: Russel and Norvig, *Introduction to Artificial Intelligence*, 3rd edition
- 5 homeworks (35%), midterm exam (20%), project (35%), participation (10%)
- Project: proposal, interim report, final report, short presentation, poster



BUREAUCRACY

- Let us know if you did not receive an email from me on Monday
- Doodle poll on recitations
- Audits: only do final project
- John is organizing an AI reading group

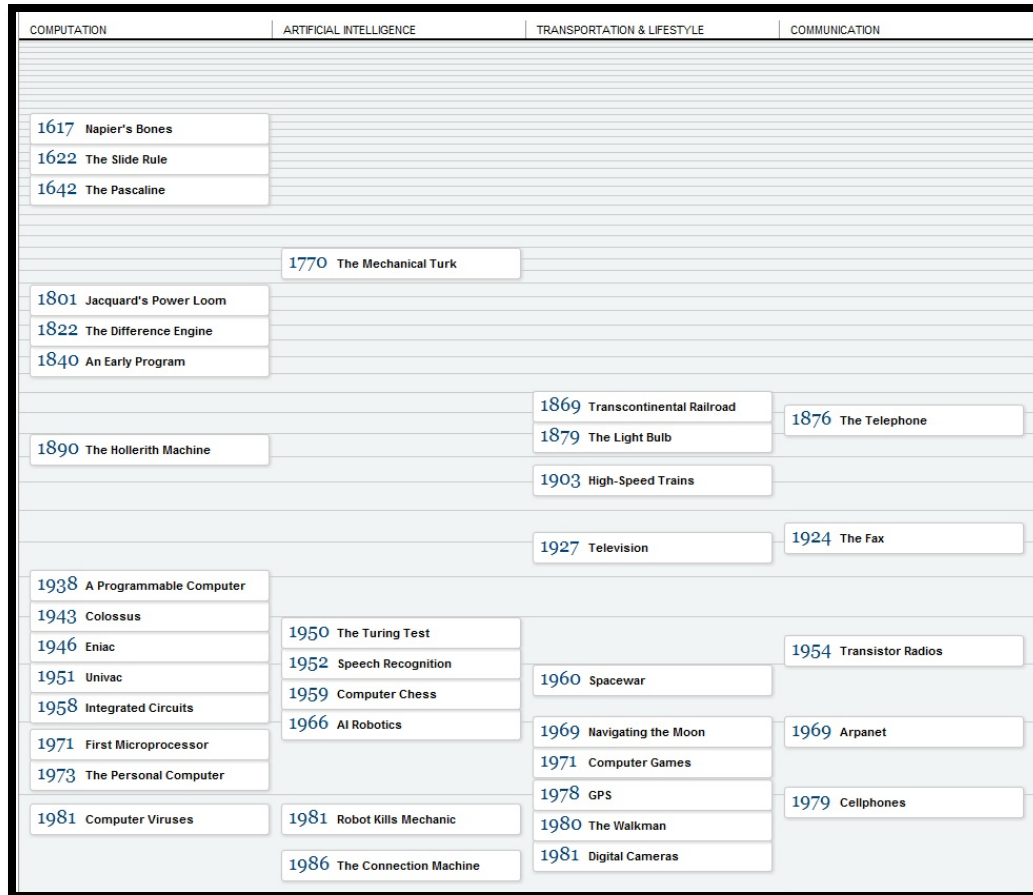


STYLE

- Probably more mathematical than the average Grad AI (nontrivial proofs on blackboard)
- Background: algorithms+computational complexity, basic probability theory, basic linear algebra, “mathematical maturity”
- Schedule shows teachers’ preferences: MAS / game theory / social choice (me), perception and motion planning (Martial)
- Fun (especially this talk)



AI TIMELINE (NYT 2011)



1770 The Mechanical Turk

A mechanical chess-playing machine awes the world, but is revealed decades later to have contained a human chessmaster hidden inside the device.

- Performed for 84 years
- Defeated Napoleon and Franklin
- Amazon Mechanical Turk: “artificial artificial intelligence”



AMAZON MECHANICAL TURK

The screenshot shows the Amazon Mechanical Turk interface. At the top, there's a navigation bar with 'Your Account', 'HITS', and 'Qualifications' tabs. Below that, a search bar allows filtering by 'HITS' containing a specific text and a minimum reward of \$0.00. The main content area displays a list of HITs, each with a title, requester name, expiration date, time allotted, reward, and number of available HITs. The list includes tasks such as 'Inv # 2', '3 questions about your city UNDER 230,000 population only = \$0.17 bonus*** - qualification instantly granted (no wait)', 'Choose the best category for this item', 'Categorize Home, Garden, and Outdoor Products', 'Help us gather product prices for another web site, yet again: Please check the site in the instructions.', 'Help us gather product prices', 'Verify Home, Garden, and Outdoor Product Categorization', 'Copy Text from Business Card', and 'Are these two pictures of the same kind of place? (NEW)'. The bottom of the screenshot shows a Windows taskbar with various application icons and system tray information.

Requester	HIT Expiration Date	Time Allotted	Reward	HITs Available
rehz0dd	Feb 8, 2012 (3 weeks 6 days)	48 minutes	\$0.00	27868
WSQVC_CDM	Jan 17, 2012 (6 days 0 hours)	3 hours	\$0.00	20531
Nic Lowe	Jan 19, 2012 (1 week 1 day)	60 minutes	\$0.01	12304
Dolores Lebs	Jan 18, 2012 (6 days 23 hours)	60 minutes	\$0.12	9967
Michael Turon	Jan 18, 2012 (6 days 16 hours)	60 minutes	\$0.01	9559
Michael Turon	Jan 18, 2012 (6 days 22 hours)	60 minutes	\$0.01	9881
Dolores Lebs	Jan 18, 2012 (6 days 23 hours)	60 minutes	\$0.10	8728
Oscar Smith	Jan 11, 2012 (1 hour 59 minutes)	10 minutes	\$0.02	8388
Michelle Greene	Jan 9, 2013 (51 weeks 6 days)	10 minutes	\$0.02	8096



1950 The Turing Test

Alan Turing proposes the Turing test to decide if a computer is exhibiting intelligent behavior.



- Big question: can machines think?
- More concrete question: can machines do well in the *imitation game*?
- Judge communicates via text channel with computer and human, must reliably identify the computer



THE CHINESE ROOM

- Thought experiment proposed by Searle
- Suppose AI has produced a program that can pass the Turing Test in Chinese
- You have a handbook with its pseudocode
- You're in a closed room and receive Chinese characters through a slot
- You run the program's code manually and return the output
- Does this mean you *understand* Chinese?



COUNTERARGUMENTS

- Finding the mind: the whole system understands Chinese, the person is just a part of the system
- Redesigning the experiment: suppose the program simulates the actions of every neuron in the brain of a Chinese speaker



COUNTERARGUMENTS

- Doubts about the intuition
 - Brain performs 100 billion operations per second, so it would take the person millions of years to simulate a simple answer
 - Churchland's Luminous Room: suppose you are standing in a dark room and quickly moving a magnet up and down, then by Maxwell's theory of artificial luminance it will be luminous. However, this requires 450 trillion movements per second



1952 Speech Recognition

Bell Labs develops the first effective speech-recognition device using splitter technology similar to the one developed by Alexander Graham Bell 78 years earlier.

- “Audrey” could recognize digits spoken by a single voice
- In 1962 IBM demonstrated “Shoebox”, which could understand 16 words
- Biggest milestone in the Seventies: CMU’s “Harpy” system, which could understand 1011 words ~ vocabulary of three-year-old



1959 Computer Chess

Arthur Samuel's checkers program wins games against the best human players. 48 years later, the game of checkers is solved by computers.

- Samuel's program was based on alpha-beta pruning
- Actually only competed at "respectable amateur" level
- By the Nineties checkers programs were beating the "best human players"
- Checkers was solved by Jonathan Schaeffer in 2007 after 18 years of calculation



1966 AI Robotics

The Stanford Research Institute creates Shakey, the first mobile robot that can reason about its surroundings. Five years later, funding is canceled when the shortcomings of the machine become apparent. Also in 1966, Joseph Weizenbaum creates Eliza, a conversational program intended to mimic a human therapist typing at a computer terminal.



Robert Reinhold/The New York Times

- Shakey = first mobile robot to visually interpret environment
- Can locate items, navigate around them, and reason about its actions
- <http://www.youtube.com/watch?v=qXdn6ynwpiI> (4:08)



1997 Deep Blue

I.B.M.'s Deep Blue computer defeats Garry Kasparov, the world chess champion. Deep Blue can evaluate 200 million chess positions per second.



Jack Manning/The New York Times

- Started as “ChipTest” at CMU, followed by “Deep Thought”
- After graduation, developers were hired by IBM
- Defeated Kasparov 3.5-2.5 in 1997
- Kasparov played anti-computer opening moves to get Deep Blue out of its opening book
- Kasparov accused IBM of cheating

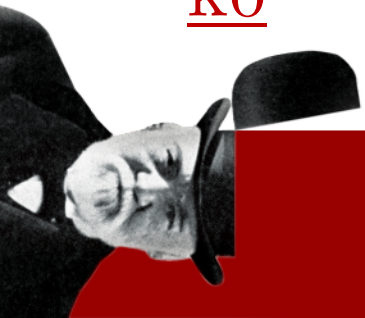


- **A**dvanced **S**tep in **I**nnovative **M**obility
(resemblance to Asimov is a coincidence)
- Can recognize moving objects, postures, gestures, its surrounding environment, sounds and faces, which enables it to interact with humans
- <http://www.youtube.com/watch?v=NZngYDDDfW4>



DARPA URBAN CHALLENGE

- 96 km urban area course, to be completed < 6 hours, took place in 2007
- Tartan Racing (CMU+GM) claimed the \$2 million prize
- Challenge involves mission planning, motion planning, behavior generation, perception, world modeling
- <http://www.youtube.com/watch?v=1ULl63ERek0>



2011 Watson Wins 'Jeopardy!'

Watson, a supercomputer built by I.B.M., defeats the two best "Jeopardy!" players in a three-day competition.



Carol Kaelson/Jeopardy Productions, via Associated Press

- Watson defeated the two greatest-ever Jeopardy! champions
- Involves natural language processing, information retrieval, knowledge representation and reasoning, and machine learning
- <http://www.youtube.com/watch?v=oUj9AzSE9c>

THE FUTURE

2017	Routine Voice Interaction
2019	Dr. Computer
2022	Premade Decisions
2038	Robot Wars

2048	Cybernetic Intelligence
2053	Artificial Intelligence
2087	Memory Backup
2190	A.I. Awarded Citizenship
2195	Cyborg Viruses
2296	A.I. Government



THE TECHNOLOGICAL SINGULARITY

- Emergence of superhuman intelligence
- Key idea: self-improvement
- Source of name: analogy between inability to predict events after the development of a superintelligence, and the space-time singularity beyond the event horizon of a black hole
- Some predict: this century
- Others argue: never



WHAT IS AI?

- Simplest (but self-referential) answer: look at the call for papers of the International Joint Conference on Artificial Intelligence



IJCAI'11 CALL FOR PAPERS

- Agent-based and multiagent systems
 - The vision: electronic commerce, supply chains, defense systems managed by autonomous software agents
 - Cooperation and coordination
 - Emergent behavior
 - Computational game theory and computational social choice



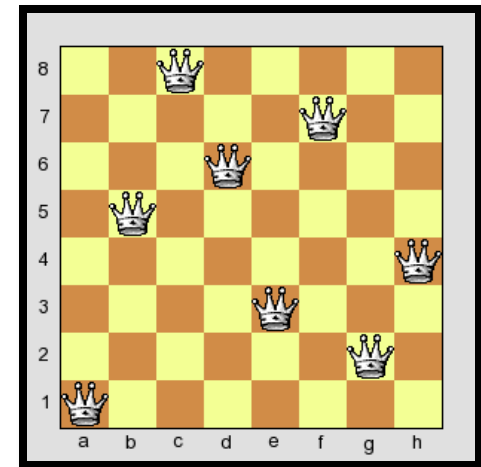
CAN GT ENABLE CLASSIC AI?

- Classic AI seeks to design intelligent robots/agents
- GT distills rationality
- Rationality is *perceived* as intelligence
- Game-theoretic MAS may be perceived as intelligent
- GT enables AI on the multiagent level!



IJCAI'11 CALL FOR PAPERS

- Search and constraints
 - Uninformed search
 - Informed search
 - Constraint satisfaction can be seen as searching through assignments
 - Conditions for backtrack-free search
 - Existence of satisfying assignments



IJCAI'11 CALL FOR PAPERS

- Planning (and scheduling)
 - Classical planning
 - Motion/path planning
 - D^* = compute path under assumptions, recalculate when new information is discovered



IJCAI'11 CALL FOR PAPERS

- Uncertainty in AI
 - Bayesian networks
 - Graphical models
 - Markov decision processes
- (Robotics and) Vision
 - Object recognition
 - Scene understanding



OBJECT RECOGNITION



From Martial Hebert

Carnegie Mellon University 28

NOT COVERED

- Machine learning
- Natural Language Processing
- Knowledge representation and reasoning
- Web and knowledge-based information systems



THEMES

- Complex environments → representation
- Complex environments → large size → heuristics
- Mimic natural world / human societies
- Synergies between different subdisciplines



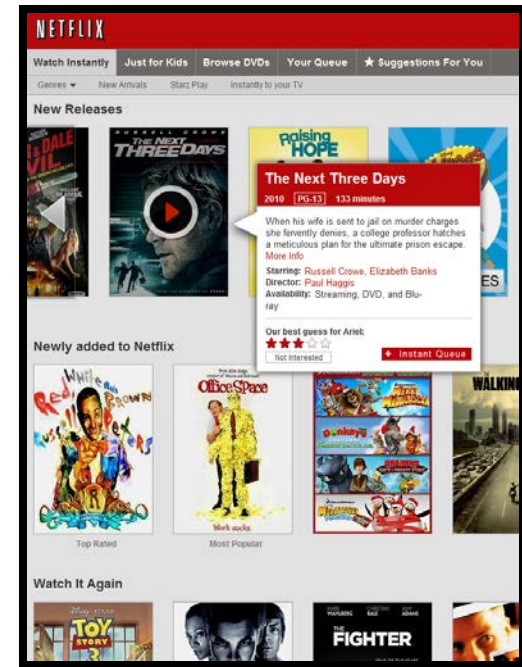
ROBOCUP

- Robotic soccer competition
- Official goal: By mid-21st century, a team of fully autonomous humanoid robot soccer players shall win the soccer game, complying with the official rule of the FIFA, against the winner of the most recent World Cup
- Components are similar to autonomous driving, with a multiagent twist
- <http://www.youtube.com/watch?v=VaXtnqjk4Bc>
(1:40)



RECOMMENDER SYSTEMS

- Step 1: find users with similar ratings
- Step 2: recommend item based on their ratings
- Common model for collaborative filtering



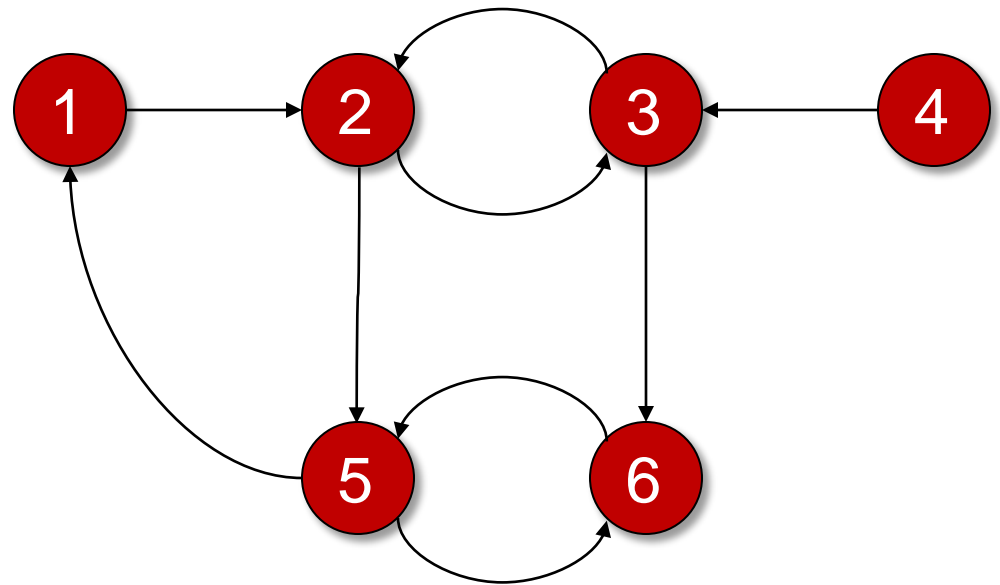
KIDNEY EXCHANGE

- In US, $\geq 50,000$ /yr are diagnosed with lethal kidney disease
- Cure = transplantation, but cadaver kidney have a long waiting list (2-5 yrs)
- Potential donors may be incompatible with patient
- Pairs of incompatible donor-patient pairs can sometimes exchange kidneys



OPTIMIZING KIDNEY EXCHANGE

- Cycle cover = optimize matched vertices under cycles of length $\leq L$
- Problem is NP-hard
- Regularly solved by our TA!



CHALLENGES

- Uncertainty: people enter and leave the pool, matches fail → stochastic optimization
- Hospitals manipulate by hiding some of their patients and matching internally → game theory / mechanism design

