CS 225
ARTIFICIAL INTELLIGENCE RESEARCH
Prof. E.A. Feigenbaum

Organizational Meeting

Time: 12:30
Day: Friday, Oct. 3
Place: Serra House Conference Room
Date: September 19, 1974

To: Computer Science Faculty, Advisers, and Computer Science students

From: Edward A. Feigenbaum, Professor of Computer Science

Subject: CS 225 - Artificial Intelligence Research

The initial organizational meeting of CS 225 will take place on Thursday, September 26 at 4:15 in Bio. 151.

CS 225 is the intermediate course in Artificial Intelligence. It is largely a workshop course in which students carry out small projects relating to ongoing AI research topics. The catalog course description is given below:

225. Artificial Intelligence Research -- Intermediate-level examination of problems of artificial intelligence research. Generality in problem-solving systems; theorem proving by computer; semantic information processing; problem representation; perceptual and effector processes; scientific reasoning processes. Not recommended for first-year graduate students. Research project involving computer program will be required. Prerequisites: 206 and 224 or equivalents. 3 units.

EAF:dl
Advices

✓ Brakett
✓ Benford
✓ Cerf
✓ Chvatal
✓ Brzozowski
✓ Feigenbaum
✓ Floyd
✓ Galab
✓ Green
✓ Herrin
✓ Knuth
✓ Luckham
✓ McCarther
✓ Mccluskey
✓ Olszews
✓ Fajian
✓ Hinograd
I. Instructor's Office: Serra House (CS Dept. Adjunct Bldg.)
Office Hours: After class Tuesday and Thursday, or by appointment at other times.

II. Textbook: Computers and Thought
Feigenbaum and Feldman, eds.

III. Purpose and Rationale:
Unlike the Fall Quarter course (CS 224), which is intended to be a broad but not probing survey of artificial intelligence research, this course is designed to give the student an in-depth look at one of the fields of work in A. I. research; to develop his or her research skills via the accomplishment of a non-trivial project; and to expose the student to complex research problems and issues of a more general sort in A. I. research. The primary vehicle of the course is the Research Workshop, a small group consisting of a few students and a workshop leader (a faculty member, lecturer, or research associate). In general, a project to develop a working program of some interest will be required of each student (team efforts are allowed).

IV. Prerequisites
1. CS 224, because this course builds upon it.
2. Introduction to Symbolic Computation (LISP Programming) or equivalent (upon the judgment of the Instructor).
   One quarter of introductory programming experience, such as CS 105 or CS 106, is not sufficient.

V. Requirements
1. Final Exam covering lectures and suggested reading. (This will count for 1/4 of the grade in the course.)
2. Final report on research project, due at the Final Exam. (The project and its final report will count for 1/2 of the grade in the course.)
3. Mid-term Project Report. To report the status of project formulation and intermediate progress. (Will count as 1/4 of grade in the course.)
4. One-page progress reports, due on February 1 and on February 29, to report increments of progress.

VI. Other
1. The course may be taken pass-fail.
2. No Incompletes will be given for unfinished projects or other reasons (except dire personal emergency; see Instructor).
3. At the time of the Feb. 1 progress report, "bank accounts" of $100/student for computing services will be assigned. If project formulation work or early-in-the-quarter research raises the need for early assignment of a bank account, contact the Instructor or the TA.
4. If you are an authorized user of the A. I. Project's PDP-10 and wish to use it for your work, that is OK.
VII. Scheduling
Tuesdays, 1:15 p.m....meetings-of-the-whole to consider topics of general
interest in A. I. research. Usually led by Feigenbaum.
Thursdays, 1:15 p.m....normal time reserved for Workshop meetings.
However, for various reasons some Workshops may have to be scheduled
at other hours in the week
We will try to have Workshops report back to the group as a whole a
synopsis of their activities. The last 3 (+1) Tuesdays will be
devoted to this.

VIII. Workshop Topics
Hand-Eye Project (robotics, vision, manipulation, etc.)
(Feldman, and staff members of Stanford A. I. Project)
Problem Solving (theory, techniques, robot environments, etc.) (Nilsson,
and staff members of SRI A. I. Project)
Models of Scientific Inference, with application to chemistry (Heuristic
DENDRAL, Meta DENDRAL, synthesis processes) (Buchanan, Sridharan)
Automatic Program Formation (Feigenbaum and Green)
Information Processing Models of Human Cognition and Affect (EPAM, Parry,
Memory Models) (Colby, Feigenbaum)
Natural Language Processing and Semantic Models (Schank)
Grammatical Inference (Feldman)
Formal Theory of Knowledge and Representations (McCarthy) (remains to be
confirmed)
# C.S. 225 - Artificial Intelligence

## Prof. Feigenbaum

### Date | Topic | Lecturer or Discussion Leader | Minimum Readings
---|---|---|---
Jan. 4 | Survey of the course; intelligent behavior by machine | Feigenbaum | Introductions to Part I and II (C&T), Turing (C&T), Armer (C&T)
6 | Principles and techniques of heuristic programming - Review | Feigenbaum | |
11 | Discussion of Minsky's "Steps Toward Artificial Intelligence" | Feigenbaum | Minsky (C&T) and Appendix (CSL)
13 | Logic Theorist and Geometry Theorem Proving Machine | Feigenbaum | Newell, Shaw, Simon and Gelernter (C&T)
18 | General Problem Solver - Review | Feigenbaum | Newell, Shaw, and Simon
20 | Problems with Problem Solving Programs; some possibilities | Feigenbaum | Newell, 2 articles (CSL)
25 | Open (topic to be announced) | Feigenbaum | |
27 | Game-playing problem solvers: checkers and chess (1) [project proposals due] | Feigenbaum | Samuel (C&T); Newell, Shaw and Simon (C&T)
Feb. 1 | Chess (2) and Kalah | McCarthy | (to be announced)
3 | Introduction to advanced theorem-proving programs | Friedman | Wang (CSL) plus others to be announced
8 | Advice Taker | McCarthy | |
10 | Question-answering problem solvers; algebra word problem solver (STUDENT) | Raphael | Green et al. (C&T), Lindsay (C&T), Raphael (CSL), Bobrow (CSL)
15 | | | |
17 | Pattern recognition | | Selfridge and Neisser (C&T)
24 | Speech recognition | Reddy | Uhr and Vossler (C&T)

(CSL) = Computer Science Library
<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 1</td>
<td>The Stanford Hand-Eye Project and other plans of the A.I. Project</td>
<td>McCarthy (CSL)</td>
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<td>Inquiring systems: inductive inquiry; theory formation by programs, various designs for inquirers, the &quot;chemist's assistant&quot; inquiring system project</td>
<td>Feigenbaum and Watson (CSL) Churchman (CSL) Amarel (CSL)</td>
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## CS 225 - Artificial Intelligence

**Prof. Feigenbaum**

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Lecturer or Discussion Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 5</td>
<td>Survey of quarter's work; discussion of projects; &quot;robotology&quot; seminar I</td>
<td>Feigenbaum</td>
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<td>10</td>
<td>Discussion of &quot;Steps Toward Artificial Intelligence&quot; by Marvin Minsky</td>
<td>Reddy</td>
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<td>12</td>
<td>&quot;Robotology&quot; seminar II -- The Stanford and SRI &quot;robot&quot; projects</td>
<td>Project Staffs</td>
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<td>17)</td>
<td>Continuation of discussion of &quot;Steps Toward Artificial Intelligence&quot;. Various approaches to the Pattern Recognition problem</td>
<td>Reddy</td>
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<td>19)</td>
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<td>24</td>
<td>Survey of conference on &quot;Intelligence and Intelligent Systems&quot;</td>
<td>Feigenbaum</td>
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<td>26)</td>
<td>Question answering programs, semantic models, problem solvers with natural language input, natural language processing</td>
<td>Raphael</td>
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<td>31)</td>
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<td>Feb. 2</td>
<td>Computational linguistics</td>
<td>Friedman</td>
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<td>7</td>
<td>Some advanced computer theorem-proving techniques</td>
<td>Friedman</td>
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<td>9</td>
<td>Open</td>
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<td>14)</td>
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<td>16)</td>
<td>Principles and Techniques of game playing and machine learning</td>
<td>Samuel</td>
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<td>21)</td>
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<tr>
<td>23</td>
<td>Pattern Classification</td>
<td>Millson</td>
</tr>
<tr>
<td>28</td>
<td>Adaptive networks for pattern recognition, with applications</td>
<td>Tunis</td>
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<tr>
<td>Mar. 2</td>
<td>Program for Reasoning by Analogy</td>
<td>Kling</td>
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<td>Date</td>
<td>Topic</td>
<td>Author(s)</td>
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<td>Mar. 7</td>
<td>A Brain Oriented Approach to Artificial Intelligence</td>
<td>Arbib</td>
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<td>9</td>
<td>Inquiring systems: empirical inquiry, theory by programs, models and representations, the &quot;chemist's assistant&quot; project, logics of discovery</td>
<td>Buchanan, Feigenbaum</td>
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ARTIFICIAL INTELLIGENCE

CS 225
T Th 1:15-2:30
Room 364 (In the Quad)

Lecturers: Arthur L. Samuel and Nils J. Nilsson

<table>
<thead>
<tr>
<th>DATE</th>
<th>TOPICS</th>
<th>RECOMMENDED READINGS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1</td>
<td>Introduction, Overview of Course, Solving puzzles by finding paths in graphs.</td>
<td>Doran &amp; Michie 66 Hart et al 68</td>
</tr>
<tr>
<td>4-3</td>
<td>Heuristic Search for a Shortest Path</td>
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<td>4-8</td>
<td>Game-Playing</td>
<td>Samuel 59, Samuel 67 Greenblatt et al 67</td>
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<td>4-10</td>
<td>Continued</td>
<td></td>
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<tr>
<td>4-15</td>
<td>Solving Problems by Searching AND/OR (Subgoal) Graphs, Examples from Calculus and Geometry.</td>
<td>Gelernter 59, Gelernter et al 60, Newell et al 57, Slagle 63, Ernst and Newell 69, Nilsson 68</td>
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<tr>
<td>4-17</td>
<td>Continued</td>
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<td>4-22</td>
<td>Logic, Introduction to Theorem-Proving in the Predicate Calculus</td>
<td>Luckham 67, Robinson 67</td>
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<td>4-24</td>
<td>Resolution Methods</td>
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<td>4-29</td>
<td>Applications of Theorem Proving in Question-Answering and Problem Solving.</td>
<td>Green and Raphael 68 Green 69, McCarthy 59, McCarthy and Hayes 68</td>
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<tr>
<td>5-1</td>
<td>Connections between A.I. and Philosophy</td>
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<tr>
<td>5-6</td>
<td>The Representation Problem</td>
<td>Amarel 68</td>
</tr>
<tr>
<td>5-8</td>
<td>Midterm Examination</td>
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</tr>
<tr>
<td>5-13</td>
<td>Natural Language Question-Answering Systems</td>
<td>Simmons 65, Simmons 69, Quillian 69, Becker 69, Feldman 67</td>
</tr>
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<td>5-15</td>
<td>Semantic Data Structures</td>
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<td>5-20</td>
<td>Grammatical Inference</td>
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<tr>
<td>5-22</td>
<td>Mechanization of Speech Recognition</td>
<td>Reddy 69, Roberts 63, Guzman 68, Nilsson 69</td>
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<tr>
<td>5-27</td>
<td>Mechanization of Visual Perception</td>
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<td>5-29</td>
<td>Robots: Integrated A.I. Systems</td>
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<tr>
<td>6-3</td>
<td>Dendral, Models of Inductive Behavior</td>
<td>Feigenbaum 69</td>
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<tr>
<td>6-5</td>
<td>Future Research Problems, Recap, Discussion</td>
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*During the course, students should also read: Dreyfus 65, Minsky 61, Feigenbaum 63, Solomonoff 66, and Feigenbaum 68.*
Reading List for Artificial Intelligence CS 225


The following books are collections of papers on Artificial Intelligence, some of which are cited in the above list:


Professor E. A. Feigenbaum  
Office hours by appointment - call Kathy at x-4878 between 12:00 - 4:00 p.m.

Teaching Assistant  
Penny Bryant x-4878

Books on reserve at the Computer Science Library in Polya Hall:

- Meltzer, B., Michie, D., eds., *Machine Intelligence* 1-6
- Findler, N. V., Meltzer, B., eds., *Artificial Intelligence and Heuristic Programming*
- Feigenbaum, E., Feldman, J., eds., *Computers and Thought*
- Minsky, M., ed., *Semantic Information Processing*
- Polya, G., *How to Solve It*
- Simon, H. A., *The Sciences of the Artificial*
- Nilsson, N., *Problem Solving Methods in Artificial Intelligence*
- Simon, H. A., Siklossy, L., eds., *Representation and Meaning*

Assignment for the first two weeks:  
Read *Artificial Intelligence Study Guide* by S. Evans and A. Newell. There are five copies on reserve in the Computer Science Library.
Course: CS225, Artificial Intelligence Research

Instructor: Professor E. A. Feigenbaum

Teaching Assistant: Dennis Brown

Office Hours: Feigenbaum, Wednesday, 2-4, Serra House (upstairs)
Brown, Tuesday, 12-2, or by appointment, Serra House (upstairs)

Phone: ext. 7-4878

This is the intermediate level course in artificial intelligence research. The presumption is that the student has taken the introductory survey course CS224, and has taken CS206 (Computing with Symbolic Expressions, i.e., LISP), or its equivalent. If you do not have these prerequisites, please drop this course (or discuss the issue with me after class).

The course is designed primarily as a workshop/projects course. The students will be divided up into small-size workshop groups, each under the leadership of an AI investigator who has a working knowledge of the workshop area and a set of ongoing projects or ideas. These workshop groups will meet independently, at times to be arranged between workshop leader and students, and at places convenient to the pursuit of the research. Computing resources as needed will be made available from various sources. The student is expected to complete a project—generally a completed and running AI program—during the quarter. It is unlikely that continuation of a workshop project into another quarter will be granted (because of lots of trouble in the past in seeing such projects through to completion). The only grading in the course will be on the basis of the quality of the research work done on the workshop project. There will be no exams. To summarize: this course is oriented toward small research projects in artificial intelligence. It is as much a "do" course as a "think" course.

The secondary purpose of the course is to expose to the student at an intermediate, and therefore fairly detailed level, a set of problems, difficulties, global views, issues, newly-developing areas, new techniques, etc., in artificial intelligence research. This is an attempt to deepen the broad perspective the student receives in CS224. This will be accomplished by lectures, panels, and class discussions, involving Feigenbaum (mostly) and other AI researchers. We will be scheduling 8-10 such sessions regularly spaced throughout the quarter. We must jointly decide on the most appropriate time in the week for holding such sessions. Thereafter, a schedule of dates and topics will be worked up and distributed.

As a way of getting started toward the gaining of global perspective, I have asked my SRI colleague, Dr. Nils Nilsson, to deliver a version of the invited lecture he gave at the international computer congress held in Stockholm in August (IFIP74 Congress). His talk will be Thursday, October 3, 4:15, in Bio. 151.
There follows a list of possible workshop areas from which a subset will be chosen on the basis of student interest and "leader" availability. Please give me a 1-2-3 ranking of your interest in these topics, by the end of today's session if possible, otherwise by the latest early next week through the departmental mail, so the formation of the workshops can begin as soon as possible.

Possible workshops (ordering implies no particular priority)

Natural Language Understanding
   for text
   for speech (speech understanding research)
Visual Scene Analysis
Manipulation (and maybe vision) as applied to industrial problems
Applications Areas:
   Bio-medicine, e.g., classical genetics
   Other science domains, e.g., chemistry, physics, crystallography, etc.
   Intelligent interfaces to real computer systems
      (e.g., ARPANET, Send Message facility, File Transfer protocols,
      specialized services, adaptivity to user desires)
Diagnosis and Treatment Planning
   of machine failures
   of disease
   of program failures (debugging)
   Useful semantic net associative memory models
Scientific Theory Formation (Meta-DENDRAL and DENDRAL)
Automatic Program Synthesis
Problem Solving and Planning
Theorem Proving
Information Processing Psychology—models of human memory, learning, and problem solving
Knowledge-Based Systems Designs:
   Knowledge acquisition—modes and techniques
   Knowledge deployment strategies
   Knowledge representation
      formal systems in mathematics and mathematical logic
      procedural representations
      production systems
Artificial Intelligence Languages

Feel free to suggest additions to this list of possible workshop areas.