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An Artificial Intelligence Course in a Liberal Arts Program

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Lindenwood College is a co-educational liberal arts college, enrolling 450 full-time traditional age students in the day program, and another 1200 part-time students in the evening division. The Computer Science major has finished its fourth full year, with approximately 35 majors in the day and evening programs. The Mathematics and Computer Science Department has four full-time faculty members, 1 full-time in computer science, 2 full-time in mathematics, and 1 who splits his time between mathematics and computer science. We also have several adjunct faculty who teach primarily in the evening division.

The department has a Departmental Computer Center consisting of a PDP-11/44 running the UNIX™ operating system, with 12 terminals, 8 in a laboratory for students, and 4 in faculty offices. In addition, there are a number of Apple IIe microcomputers, four IBM PC/XT's and an Apple Macintosh SE, housed in a new microcomputer laboratory.

The Computer Science major follows the ACM Curriculum '78 guidelines[1,2,3] for the Core curriculum in Computer Science, with 8 courses in computer science and 5 associated courses in mathematics required for the major. During the 1986-87 academic year, the department offered the first elective in computer science, a course in Artificial Intelligence.

The Artificial Intelligence Course

Artificial Intelligence provides a unique opportunity to examine historical, philosophical and ethical topics and issues in a computer science course. This makes it an excellent elective for a program in a liberal arts setting.

Purpose and Audience

The purpose of the Artificial Intelligence course was to expose the students to the major areas and techniques of AI, to give them a sense of the history of man's attempts to duplicate himself, both physically and intellectually, and to examine some of the social and philosophical issues surrounding the modern study of artificial intelligences.

The audience was made up of Computer Science majors, most of whom were juniors and seniors. Although the prerequisites for the course were the Elementary Algorithms and Discrete Mathematics courses, most of the students had considerably more computer science than the minimum required. The appendix contains the syllabus for the course, listing topics and requirements.

How the Course Went

The course went very well for a first time offering, at least from the instructor's point of view. We spent most of the first three weeks of the course discussing history and philosophy. Most of the material on the history of AI and automata came from Pamela McCorduck's book Machines Who Think. This section seemed to alternate between silence and lively discussion. One of the good things about discussing philosophy in a computer science course is the opportunity to bring to bear a very different perspective on issues that may have seemed irrelevant on first exposure. Cartesian dualism becomes much more interesting to students when discussed in conjunction with Alan Turing's paper on "Computing Machinery and Intelligence".



Much of the rest of the material in the course came from Charniak and McDermott (the required text), Winston, and Tanimoto. In retrospect, I feel that Charniak and McDermott was not a good choice for a first undergraduate course in Artificial Intelligence. It is fairly difficult to read, the algorithm presentation is fuzzy, there are not very many completely worked examples, and the order of presentation of topics makes it difficult to grasp Artificial Intelligence as a whole.

Teaching Lisp as part of the course was not burdensome. All of the students in the class knew both a high-level procedural programming language (Pascal) and an assembly language, so the acquisition of a new language presented few problems. The major problem with learning Lisp seemed to be its functional nature and the central idea of exactly when and how "evaluation" takes place. Students schooled previously in exclusively procedural languages had some difficulty in changing their mind-set to think recursively and functionally. Four Lisp programs of increasing difficulty were required over the course of the semester, starting with a program to find the union of two lists (an easy recursive program, somewhat harder if its done iteratively) and ending with a simple game playing program.

Bibliography

With the exception of the textbooks, all the references below were included in the reading list for the course and material for lectures was drawn from a number of them. Students were required to write two 1-3 page reports summarizing the book/article, giving their interpretation of the salient points raised and making any comments they deemed appropriate. These reports were required for two reasons. First to have the students read something besides their text and to begin to familiarize them with the literature on AI. Secondly, the reports were intended to provide an introduction to technical writing. Reports were graded for content, grammar and style, returned to the students who then resubmitted below standard reports.

Not surprisingly, no students chose the nonfiction books to read and report on. On the

other hand, none of the fiction books were chosen nor were any of the BYTE magazine articles. Reports came exclusively from Scientific American, and the ACM and IEEE publications.

Textbooks

Charniak & McDermott, "Introduction to Artificial Intelligence," Addison-Wesley, 1985.

Rich, E., "Artificial Intelligence, McGraw-Hill, 1983.

Tanimoto, S., "The Fundamentals of Artificial Intelligence," Computer Science Press, 1987.

Winston, P., "Artificial Intelligence," Addison-Wesley, 1984.

Nonfiction Books

Bernstein, J., "Science Observed," Basic Books, 1982. Essays 1, 2, and 3 (about Marvin Minsky) and 17 "A.I."

Dreyfus, H. "What Computers Can't Do," Harper Colophon Books, 1979. An existential philosopher's arguments against AI. Dreyfus is mentioned in Rose's and McMurdock's books.

Feigenbaum, E. and Feldman, J., "Computers and Thought," McGraw-Hill, 1963. Old, but contains several seminal papers, like Turing's (Turing test paper), and Newell and Simon's paper on GPS.

Gardner, H., "The Mind's New Science", Basic Books, 1985. A history of the development of cognitive science.

Hofstadter, D. and Dennett, D., "The Mind's I", Basic Books, 1981. An anthology about mind, computers and AI; includes Turing's paper on machine intelligence and selections from Godel, Escher, Bach. Also includes criticisms of AI (Searle).

Hofstadter, D., "Godel, Escher, Bach: The Eternal Golden Braid, Basic Books, 1979.

McCorduck, P., "Machines Who Think," W.H. Freeman & Co., 1979. A very well done history of AI.

Mowshowitz, A., "Inside Information," Addison-Wesley, 1977. An anthology of

Computers in Fiction, along with commentary and criticism.

Raphael, B., "The Thinking Computer," W.H. Freeman and Co., 1976. For the advanced layman. General AI, as of 1975.

Rose, F., "Into the Heart of the Mind, Harper and Row, 1984. Story of Wilensky and his students at Berkeley in 1982. Layman oriented, but some good explanations.

Simon, H. "The Sciences of the Artificial," MIT Press, 1969. Simon's definition of AI. The origin of the "ant on a beach" analogy.

Weizenbaum, "Computer Power and Human Reason," W.H. Freeman & Co., 1976. Weizenbaum's arguments against AI based (at least partially) on his experiences with Eliza.

Fiction

Gerrold, D. "When Harlie was One," Nelson Doubleday, 1977.

Heinlein, R. "The Moon is a Harsh Mistress," Berkeley Medallion Books, 1966.

Hogan, J. "The Two Faces of Tomorrow", Ballantine Books, 1979.

Ryan, T. "The Adolescence of P-1," Collier Books, 1977.

Scientific American articles

Hofstadter, D. "Metamagical Themas" column Scientific American, March, 1983. On Lisp.

Horn, B., "The Mechanical Manipulation of Randomly Oriented Parts", Scientific American, August, 1984.

Lenat, D., "Computer Software for Intelligent Systems," Scientific American, September, 1984.

Poggio, T., "Vision by Man and Machine," Scientific American, April, 1984, p. 106.

Waltz, D., "Artificial Intelligence," Scientific American, October, 1982.

Winograd, T., "Computer Software for Working with Language," Scientific American, September, 1984.

BYTE Magazine Articles

Deering, M., "Architectures for AI," BYTE, 10:4, April, 1985.

Hinton, G., "Learning in Parallel Networks," BYTE, 10:4, April, 1985.

Feldman, J., "Connections," BYTE, 10:4, April, 1985.

Michaelsen, R., et.al., "The Technology of Expert Systems," BYTE, 10:4, April, 1985.

Schank R., and Hunter, L., "The Quest to Understand Thinking," BYTE, 10:4, April, 1985.

Stevens, J., "Reverse Engineering the Brain," BYTE, 10:4, April, 1985.

Thompson, B. and Thompson, W., "Inside an Expert System," BYTE, 10:4, April, 1985.

ACM Articles

Bobrow, D., et. al., "Expert Systems: Perils and Promise," CACM, 29:9, September, 1986, pp. 880-894.

Fikes, R. and Kehler, T., "The Role of Frame-Based Representation in Reasoning", CACM, 28:9, September, 1985, pp. 904 - 920.

Genesereth, M. and Ginsberg, M., "Logic Programming," CACM, 28:9, September, 1985, pp. 933-941.

Hayes-Roth, F., "Rule Based Systems", CACM, 28:9, September, 1985, pp. 921-932.

Newell, A. and Simon, H.A., "Computer Science as Empirical Inquiry: Symbols and Search", CACM, 19:3, March, 1976.

Ourusoff, "The Physical Symbol System Hypothesis of Newell and Simon: A Classroom Demonstration of Artificial Intelligence", SIGCSE Bulletin, September, 1985.

Stanfill, C. and Waltz, D., "Toward Memory-based Reasoning," CACM, 29:12, December, 1986, pp. 1213-1229.

Wilensky, R., et. al., "Talking to UNIX in English: An Overview of UC", CACM, 27:6, June, 1984, pp. 574-593.

Winston, P., "Learning and Reasoning by Analogy," CACM, 23:12, December, 1980, pp. 689-703.

IEEE Computer Articles

July, 1986 issue has several articles on expert applications

Fahlman, S.E. and Hinton, G.E., "Connectionist Architectures for Artificial Intelligence," Computer, 20:1, January, 1987, pp. 100-109.

Ramamoorthy, C. et.al., "Software Development Support for AI Programs," Computer, 20:1, January, 1987, pp. 30-42.

Waltz, D., "Applications of the Connection Machine," Computer, 20:1, January, 1987, pp. 85-99.

References

[1] Curriculum '78: Recommendations for the undergraduate program in computer science - A report of the ACM Curriculum Committee on Computer Science. CACM, 22:3 (March, 1979), pp. 147-166.

[2] Koffman, E.B., Miller, P.L., and Wardle, C.E. Recommended curriculum for CS1, 1984. CACM, 27:10 (October, 1984), pp. 998-1001.

[3] Koffman, E.B., Stemple, D., and Wardle, C.E. Recommended curriculum for CS2, 1984. CACM, 28:87 (August, 1985), pp. 815-818.

APPENDIX - Course Syllabus

CSC 311 - Artificial Intelligence
Spring, 1987

Required Text: Introduction to Artificial Intelligence, by Charniak and McDermott, Addison-Wesley, 1985.

Course Requirements

There will be three (3) tests and a final exam, each worth 20% of your grade, several LISP programs worth 10%, and 2 article reports, also worth 10% of your grade.

The Lisp programs will be relatively simple and will illustrate some of the decision making and search strategies we will be learning. They will require the standard documentation we've used for all programs. All our programming will be done on the PDP-11/44 (diana) using the Berkeley Lisp interpreter. Those of you who don't yet know UNIX or vi will have to learn these before you'll be able to learn Lisp. I have available 2 documents describing UNIX and vi that people may request. They will be on reserve in the library.

In addition, the Berkeley Lisp interpreter does not exactly match the version of Lisp in the text, so I will make available a Lisp Primer and Reference Manual for our interpreter. We will be having labs on Fridays from 9 - 10:15 am in 309 Young.

I will be handing out a list of journal articles and books on topics in Artificial Intelligence. All the articles will be available in the library, some of them in journals, the remainder on in-house reserve. These articles and books have been picked to give you a different perspective on AI than you find in the text. The reports you write should be summaries of the major topics and ideas in the books or articles, along with your analysis (including agreement or disagreement) of those ideas. Do not just paraphrase the articles! You must report on at least one journal article. (This means you can't report on two books; either two journal articles or one book and one journal article.)

Your reports should be 1 - 3 pages long (typewritten preferred) and I will be taking off points for incorrect grammar and style - the further you go in your career (whatever it ends up being), the more writing you will have to do.

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will complicate the problem considerably from the point of view of passing instructions.

5. Change the PROGRAM to do something more interesting such as computing Fibonacci numbers or $n!$ (iteratively, not recursively). We note that projects involving all of the options 11-5 have been successfully used in a first course at Howard University. 6. Change the nature of the input. For example, instructions can be 16-20 bits long with the first 4 reserved for an OPCODE and the remaining fields of bits representing one or two MEMORY addresses. The project can be designed to do all arithmetic in binary or to convert to decimal and do all arithmetic in decimal. The second is probably somewhat easier. Both of these options would make the exercise somewhat difficult in a first course.

7. Change the hypothetical computer to allow indirect addressing in INSTRUCTIONS or to have PROGRAMS that generate so much data that the two will overlap. These ideas would probably complicate the project too much for a first course. They may be appropriate for a long project in a second course in Computer Science in which the students learn a new language.

Acknowledgements Many thanks to V. Sigillito of John Hopkins University who introduced me to the idea of giving emulator projects in advanced courses. Many thanks also to the students at Howard University who suffered through several versions of these projects in beginning programming classes.

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Course Outline

We will be covering all of chapters 1 and 2 of Charniak and McDermott (C&M), and parts of chapters 4 through 9. This is a survey of Artificial Intelligence in a liberal arts context, so while we will examine many of the major areas of AI, we will be concentrating on knowledge representation, search strategies, and the social implications of intelligent machines.

The first third of the course will concentrate on history, logic and Lisp. Logic and Lisp are the two languages of artificial intelligence; the predicate calculus is the basis for almost all the knowledge representations used, and Lisp and its dialects are the programming languages used for most AI programs to date.

The middle third of the course will concentrate on knowledge representation and search strategies, two of the most important research areas in AI. These two areas are intimately involved in the analysis of how we think, including how our brains are organized, how we store information, how we see and move and speak, how we make analogies, how we go about solving all sorts of problems, and how we can design programs and machines to simulate these human actions.

The last part of the course will concentrate on other areas of AI, including expert systems, robotics and the social implications of artificial intelligence. We'll also talk about whether some kinds of AI research should be done at all, and if we can really design an "intelligent" machine (and if we should).

Tests - approximate dates

Test 1: Monday, February 23, 1987, covering chapters 1 2 of C&M.

Test 2: Monday, March 23, 1987, covering knowledge representation and chapter 4.

Test 3: Monday, April 13, 1987, covering chapters 5 and 6.

Final: Monday, May 4, 1987, 9:00-11:00am covering chapters 7, 8, and 9.

The first article report is due the Friday before Spring Break (March 6, 1987), the second report is due the last day of classes.