Artificial Intelligence as the Liberal Arts of Computer Science

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Abstract

I suggest that artificial intelligence be presented as a broad, interdisciplinary, humanistic area of study taught through several courses. I suggest avoiding problem sets, examinations, and other elements of engineering pedagogy; I advocate curriculum structures that encourage original student research, self-directed programming projects, and the development of connections between diverse topic areas. This short paper describes a "liberal arts" approach to introductory artificial intelligence education and the implementation of this approach in the cognitive science program at Hampshire College.

1 Liberal Arts

I use the phrase "liberal arts" in the modern sense — I refer not to the ancient "trivium" and "quadrivium," but to a view of undergraduate education as a broad, humanistic enterprise. The suggestion that AI be viewed as the liberal arts of computer science has three intended readings:

1. AI intersects with many of the traditional liberal arts (psychology, philosophy, literature, music, etc.) and these intersections should be highlighted and exploited.

2. AI intersects with all of the traditional divisions of computer science (algorithms, theory, programming languages, parallelism, etc.). AI can be viewed as a central discipline of computer science and as an organizing structure for computer science education; this view leads to benefits both for AI and for computer science as a whole.[1]

3. "Liberal arts education" refers not only to a collection of subjects, but also to a pedagogical strategy that involves breadth of knowledge, attention to primary sources, an emphasis on independent scholarship, etc. These strategies should also be applied to introductory AI education.

2 The Approach

AI is a broad area of study with close connections to a wide range of disciplines outside of computer science. AI is also "interdisciplinary" with respect to the traditional subdisciplines of computer science; this makes it possible for AI themes to serve as organizational structures for larger computer science curricula.

These observations lead to the suggestion that introductory artificial intelligence be presented in much the same manner as liberal arts colleges present the full scope of advanced education. Modern liberal arts pedagogical methods are successful in introducing students to large, diverse, interconnected bodies of knowledge; they can be similarly successful in introducing students to the large, diverse, interconnected bodies of knowledge that constitute AI.

One might apply liberal arts methods to the teaching of artificial intelligence in a variety of ways. I make the following specific recommendations:

1. Problem sets, examinations, and other elements of engineering pedagogy should be avoided.

2. Debates, discussions, student presentations, role-play activities, and other elements of modern liberal arts pedagogy should be examined for their applicability to AI content.

3. Classroom discussion should be encouraged, and student input should be solicited in determining topics for discussion sessions.

4. Original student research and self-directed programming and writing projects should be encouraged.

5. Courses should be designed to require minimal prerequisites; this allows students to approach AI from a variety of backgrounds and fosters the diversity of viewpoints within classes.

6. Problems should be approached from consideration of the human context in which the problems arise. For example, natural language processing should be introduced via human psycholinguistics, or via discussions of the social implications of conversational machines, rather than via engineering concerns about parsing systems.

7. AI concepts should be presented within a broad historical context that includes developments in all of the cognitive sciences.

8. Connections to seemingly distant disciplines in the liberal and fine arts — painting, dance, social history, etc. — should be fostered whenever possible; this will succeed only within institutional settings that value interdisciplinary work.

9. Since much of the "discourse" of AI occurs in the language of code, programming competence in a variety of languages should be encouraged. This is analogous to the encouragement of foreign language competence that was until recently part of the liberal arts curriculum.

10. Students should read primary literature, including code for classic AI programs, and they should produce original analyses, proposals, and programs in response. AI is one of the few areas in computer science in which both classic and current advanced research papers are likely to be intelligible to students at the introductory level.

[1] Barbara Grosz made a similar point in her AAAI Presidential Address at AAAI-94.

Few would suggest that an adequate introduction to the liberal arts can be achieved in a single course; correspondingly, a corollary of my position is that we should not be trying to construct the ideal introductory AI "course," but rather the ideal introductory AI curriculum. Some of the components of the liberal arts approach could be applied in a single, isolated introductory AI course, but I believe that significant advances in introductory AI education will occur only when the one-course approach is abandoned.

One benefit of the liberal arts approach to AI is that it provides a framework within which the "smorgasbord" of AI topics can be coherently addressed. Liberal arts education is a smorgasbord that has been coherently presented by institutions of higher learning for hundreds of years; we can apply the lessons of this experience to AI education. Another benefit is that we can expect a new population of students to be drawn into the study of AI — a population of students who are drawn to courses for their connections to other disciplines, and who emerge competent to engage in AI research. Such a population of AI students will enrich the field in a variety of ways.

3 The Artificial Intelligence Curriculum at Hampshire College

Hampshire College is a small, experimenting liberal arts college that provides a unique environment for the testing of educational ideas. The College curriculum features close student-faculty collaboration, student-initiated and individualized programs of study, and critical inquiry at every level of the student's experience. Hampshire has no traditional "departments"; rather, it is divided into four broad interdisciplinary Schools, defined by mode of inquiry: Cognitive Science and Cultural Studies, Humanities and Arts, Natural Science, and Social Science. The cognitive science program, housed in the School of Cognitive Science and Cultural Studies, is the framework within which AI is taught. The cognitive science program includes faculty in psychology, neuroscience, animal behavior and cognition, linguistics, philosophy, and computer science.

Hampshire students do not earn their degrees solely by completing courses and by accumulating credits; rather, they engage in a variety of activities that fulfill requirements crafted on a per-student basis in consultation with faculty. Many of these activities are typically large-scale individual projects, completed under the close supervision of a faculty advisor. Such projects are an important part of the AI curriculum. In addition, Hampshire is a member of a five-college consortium that also includes Amherst College, Mt. Holyoke College, Smith College, and the University of Massachusetts at Amherst. Hampshire students may supplement their AI coursework with classes at any of the other four institutions.

Many of the courses in Hampshire's cognitive science program include AI content. For example, the survey course "Cognitive Science: Exploring the Nature of Mind" includes an AI module, and other courses such as "Neurophilosophy" make reference to AI concepts throughout. The Hampshire curriculum evolves rapidly, but the following courses may be considered to be the core of the current AI curriculum.

Introduction to Computer Science: Programming Creative Processes (no prerequisites) An introduction to computer science that explores the role of computers in the simulation and study of creative processes. Traditional CS1 materials are supplemented with readings and lectures on AI and Creativity, including demonstrations of "creative" AI programs and samples of their output. The class also features classroom discussions on philosophical issues related to the mechanization of creativity. Students write C programs that generate device designs, poetry, melodies, drawings, animations, etc. Collaboration is encouraged. Several class assignments have evolved into large scale independent projects completed in subsequent terms.

What Computers Can't Do (no prerequisites) A critical look at computing. The first third of the course covers in-principle and in-practice limits of AI as discussed in the philosophical literature. The second section of the course covers basic computability and complexity theory. The third section covers the social and political implications of computational limits, including the risks of AI technology applications. This course makes use of several interactive "role-play" educational activities. Final projects may be term papers or specifications for new interactive classroom activities.

Introduction to Artificial Intelligence (1 prerequisite: any college-level programming course) Covers Common Lisp and standard AI programming techniques: pattern-matching, frame systems, semantic nets, augmented transition networks, rule-based programming, search. Lectures focus on the genesis of these techniques from theories in psychology, linguistics, philosophy, etc. "Primary code" (code from classic AI programs, although sometimes reconstructed) is used whenever possible. Students produce Lisp programs of their own design to solve problems of their own choosing. Students must present their work and facilitate discussions at least twice during the semester. Final project areas have varied widely, including games, artificial life environments, knowledge representation tools, interactive sculptures, algorithmic music composition systems, etc.

Advanced Topics in Artificial Intelligence (1 prerequisite: Introduction to Artificial Intelligence) Covers CLOS and a range of advanced AI concepts (recent topics: reactive planning, genetic programming, AI in interactive arts technologies). Students collaborate on large-scale projects in the Creative Cognition Laboratory, which links a variety of programming environments to multimedia input and output devices.

Reasoning about Action (no prerequisites) Explores the cognitive and computational problems of reasoning about plans, goals, and action. Students read the primary literature of AI planning systems, along with articles on the philosophy of action and the frame problem. Students produce critical analyses of the literature and/or sketches for new approaches.

Animals and Animats: Natural and Artificial Intelligence and Behavior (1 prerequisite: either a programming course or an animal behavior course) Explores the intersection between studies of animal behavior and AI approaches to the generation of behavior, focusing on questions of animal evolution and evolution-inspired computational paradigms. Students produce critical analyses and/or original programming projects. This course is co-taught by Computer Science and Animal Behavior faculty.

4 Preliminary Results

Some of the ideas presented in this paper were implemented in Hampshire's cognitive science program at its inception (1970 — this was the first undergraduate cognitive science program in the country), while others were implemented only

within the last two years. While there is not yet a large body of data on which to report, the initial results are promising — the program seems to be generating significant local excitement, drawing liberal arts and fine arts students into the study of AI, and producing undergraduates capable of advanced, original AI research. Two papers at AAAI-94 list Hampshire student co-authors, one of whom was only in his second year of undergraduate study when the paper was completed.

5 Summary

I believe that introductory artificial intelligence should not be squeezed into a single course. It is most profitably viewed as a broad, interdisciplinary area of study — the "liberal arts" of computer science — and it is therefore best taught through a collection of courses that borrow pedagogical methods from the traditional liberal arts. I have outlined some of the specific recommendations that stem from the liberal arts approach, and have sketched the implementation of this approach at Hampshire College.

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