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Research Statement

Historians and social scientists are only beginning to explore the widespread influence of information science and technology on social structures, work practices, and the production of scientific and technological knowledge. With a few notable exceptions the literature on this history is marred by an unfortunate emphasis on the material artifacts of electronic computing (machines) rather than on their larger social context (people, processes, and power relationships). My work attempts to move beyond the history of computers as devices to address questions of general interest and relevance about computerization as a larger social, political, and intellectual phenomenon. My long-term research and teaching agenda seeks to integrate the history of information science and technology — very broadly defined to encompass a wide range of 19th and 20th century scientific, technological and social developments — into the mainstream of the history of science and technology.

My first book, *The Computer Boys Take Over: Computers, Programmers, and the Politics of Technical Expertise* (MIT Press, 2010), explored the rise to dominance of the "computer boys" in the post-war American corporation. The focus was on the ways in which these new technical specialists, by virtue of their control over the nascent technology of electronic computing, acquired institutional power vastly disproportionate to their formal role in the organizational hierarchy. My argument was that as information technology became an increasingly important part of scientific research and corporate control and communication, existing networks of power and authority were uncomfortably disrupted. The conflicting needs and agendas of computer scientists, corporate managers, government and military officials, and vocational computer programmers resulted in a highly public struggle for control over the intellectual and occupational territory opened up by the technology of computing. My study of the origins and evolution of this struggle, and the seemingly perpetual "software crisis" that it provoked, explored the series of social negotiations that have defined contemporary understandings of the role of electronic computing, and of computing professionals, in modern corporate, academic, and governmental organizations.

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One of my goals in writing this first book was to explore a currently underdeveloped aspect of the history of computing, which is the history of software. Most of what has been written about the computer is written as if the computer were a machine, a physical artifact, a tangible "thing." But most people experience the computer not as a single machine, but as many. What makes the electronic digital computer so unique in the history of technology — so powerful, so flexible, so capable of being applied to such an extraordinarily diverse range of purposes — is its ability to be reconfigured, via software, to accomplish a seemingly infinite number of applications. By installing new software, we can make our computer serve alternatively as a word processor, a video game player, a digital photo album, or a gateway to the Internet. Its uses are limited only by our imagination, which is what makes the computer so unique, and so ubiquitous. The technology, or set of technologies, that we call the computer is too complicated, too diverse, and too important to reduce to a single moment or act of invention. This makes telling the story of software an enormously difficult undertaking, one that encompasses social, labor, economic, business, and political history, as well as the history and sociology of technology. A daunting challenge — and an enormous opportunity.

My current long-term book project continues on this exploration of the history of software, documenting yet another role in which the computer-based software systems have proven broadly influential — and highly controversial. At its most basic level, it will be a history of the computer as a decision-making technology, and will focus on its use as a decision tool in the problem domains of medicine, public policy, and finance. The project focuses particularly on the movement of techniques and technologies from artificial intelligence and operations research as they migrate out of the military and scientific laboratories into a broad range of professional, commercial and governmental activities. The goal is to further expand the reach of the history of computing by connecting it with the broader social and economic history of the post-war period. The electronic computer played a crucial role in enabling new forms of technocratic expertise adopted by business schools, think tanks, and corporate bureaucracies. Paul Edwards has written about this new cybernetic mindset in terms of military planning and national defense strategy, and Jennifer Light in urban planning and development.[1] Sonia Amadae and Philip Mirowski have told similar stories about the emergence of rational choice theory and neoliberal economic theory.[2] The book will explore the underlying the way in which these social and political developments get quite literally embedded in computer software and expert systems.

Consider, for example, the case of medical expert systems:

As early as the 1950s, researchers in computer science began developing applications for use in medical diagnosis. The appeal of such systems was obvious: The automation of routine tasks would theoretically be both cost effective and more humane. Less energy would be required for clinical tasks, more time could be set aside for human issues and interaction with patients. Precious hours would be freed up for the improving of techniques and further research. Computerized diagnosis would presumably also result in better care; unnecessary testing would be reduced, fewer medical resources would be consumed, and patients would return to health more quickly. New information and techniques could be introduced immediately at little expense with no loss of valuable physician resources. Medical decision-making could become standardized and consistent. In some cases human error could be completely eliminated. In others, ethically and legally appropriate standards could be made more available and imposed more easily. Malpractice settlement and insurance costs could be reduced. Computerized systems are immune to fatigue, stress and illness, able to work 24 hours a day, seven days a week.[3]

In the late 1970s, a major shift in the research agenda of artificial intelligence occurred, centered around the development of medical expert systems.[4] This case study will explore this very significant shift, and the challenges and opportunities it posed for artificial intelligence and medical practitioners alike. The focus will be on the problem of "knowledge engineering," as the process of modeling complex cognitive activities came to be designated. Contrary to the expectations of the AI community, medical diagnosis is not a well-defined, rules- or evidence-based process. Human physicians must undergo a long apprenticeship in order to learn how to diagnose effectively; articulating the skills and tacit knowledge required for expert diagnosis in a form that computers can understand and make use of proved almost impossible.[5]

The choice of medical diagnosis as a problem domain posed a major challenge for AI researchers. It highlighted the social elements of the complex sociotechnological system that is modern clinical practice. It led to development of new techniques, and the abandonment of many of the lofty claims of the strong AI program. This particular case study will look at the role of legal and ethical considerations — particularly the need for expert systems to be able to "explain" their reasoning — in determining the structure of expert systems in medical diagnosis.[6]

In addition to providing a book-length history of computer-based decision making from the early 1950s to the early 1990s, this new research project also seeks to develop new methodological techniques for the social study of software.

It has been a major goal in the history of computing over the last decade to develop the history of software.[7] After all, it is software that makes the computer useful, software that transforms the latent power of a general-purpose machine into a specific tool for accomplishing real-world problems.[8] Software provides the link between the theoretical and the practical. It is an inherently heterogeneous system, an amorphous mix of programming, practices, and personnel, that provides the crucial link between the computer and its larger social and economic environment. Its relevance to the history and sociology of technology should be obvious. But because computer systems, and software systems in particular, are often quite literally "black boxes," they are often treated figuratively as such by historians and sociologists of technology.[9]

And so a secondary goal of this project is to "open the black box" of expert system software and other artificial intelligence technologies, and to reveal the ways in which these technologies embody, and then conceal, the social and political dimensions of human-oriented expertise and decision-making. I am particularly concerned with developing a language for talking about the ways in which values and bias, inadvertent or not, get constructed into computer system.[10] My interest in integrating a technical and social analysis of software systems has been additionally been motivated by a series of lectures on the ethics of engineering design that I give annually to students in the School of Engineering and Applied Science at the University of Pennsylvania. It is clear that there is a need for more detailed case studies of the way in which processes of social construction play out in computer technology. For this difficult task I feel that I am uniquely prepared: prior to obtaining my Ph.D. in the history of science I trained as an engineer (with a specialty in operations research and systems design), and I worked for almost a decade in software development. Over the past few years I have been working to refine my methodological abilities in this area, most recently in a forthcoming article on the significance of computer chess as the "drosophila" of artificial intelligence. The article looks very closely at the politics of the algorithm embedded in chess software, and explores the ways in which the choice of a particular algorithm (the min-max algorithm with alpha-beta pruning) shaped the research agenda in AI for decades.

I have already received a contract from the Johns Hopkins University Press for a second book. In the meantime, I am in the process of publishing three articles based on my new research project. The first, entitled "Is Chess the Drosophila of AI? A Social History of an Algorithm," has been accepted for publication in *Social Studies of Science*. The second paper is called "Why Docs Don't Do Email: Computers and Medical Decision Making," and will be submitted to the *Journal of the*

History of Medicine & Allied Sciences. The third deals with the use of computers in financial modeling. I anticipate completing this piece by the end of the semester, and intend it for submission to either *Business History Review* or *Technology & Culture*.

In addition to my current research project on computerized decision tools, I am working on several longer-term projects aimed at the larger history of science community: the practical and epistemological shifts associated with the increasing use of simulation and modeling in scientific experimentation; the role of medical informatics in the construction and reification of etiological categories; and the attempt by entrepreneurial information scientists to establish information theory as the meta-discipline' subsuming the traditional physical sciences.

Notes

[1]Jennifer Light. *From warfare to welfare : defense intellectuals and urban problems in Cold War America*. Baltimore Johns Hopkins University Press, 2003; Paul Edwards. *The Closed World: Computers and the Politics of Discourse in Cold War America*. The MIT Press Cambridge MA, 1996.

[2]S. M Amadae. *Rationalizing capitalist democracy: the Cold War origins of rational choice liberalism*. University of Chicago Press, 2003; Philip Mirowski. *Machine Dreams: Economic Agents as Cyborgs*. Vol. New Economics and Its History. 1997, pp. 13–40.

[3]O. Rienhoff et al. *Expert systems and decision support in medicine: 33rd Annual Meeting of the GMDS, Hannover, September 26-29, 1988*. Springer-Verlag, 1988, xii, 591 p; Robert Weaver. "Editorial Comments, 1974-1986: The Case For and Against the Use of Computer-Assisted Decision Making". In: *Proceedings of the 11th Annual Symposium on Computer Applications in Medical Care*. 1987, pp. 143–149.

[4]Edward A. Feigenbaum and Pamela McCorduck. *The Fifth Generation: Artificial Intelligence and Japan's Computer Challenge to the World*. Addison Wesley Publishing Company, 1983; Edward Hance Shortliffe and James J Cimino. *Biomedical informatics: computer applications in health care and biomedicine*. New York, NY: Springer, 2006, xxvi, 1037 p.

[5]B.J. McNeil, S.G. Pauker, and A. Tversky. "On the framing of medical decisions". In: *Decision Making: Descriptive, Normative, and Prescriptive Interactions*. Ed. by David Bell, Howard Raiffa, and Amos Tversky. Cambridge University Press, 1988, pp. 562–568; Marc Berg. *Rationalizing medical work: decision-support techniques and medical practices*. MIT Press, 1997.

[6]Christopher Hughes, Earl Grose, and David Roseman. "Overcoming deficiencies of the rule-based medical expert system". In: *Computer Methods and Programs in Biomedicine* (1992), pp. 393–400; William Hyman. "Legal Liability in the Development and Use of Medical Expert Systems". In: *Journal of Clinical Engineering* 14.2 (1989), pp. 157–162.

[7]Ulf Hashagen, Reinhard Keil-Slawik, and Arthur L. Norberg. *History of Computing - Software*

Issues. Springer-Verlag, 2002.

[8] Michael Mahoney. "What was the question? The origins of the theory of computation". In: *Using History to Teach Computer Science and Related Disciplines*. Ed. by Atsushi Akera and William Aspray. 2004, pp. 225–232.

[9] Stuart Shapiro. "Splitting the Difference: The Historical Necessity of Synthesis in Software Engineering". In: *Annals of the History of Computing* 19.1 (1997), pp. 20–54.

[10] Batya Friedman and Helen Nissenbaum, eds. *Human Values and the Design of Computer Technology*. Cambridge University Press New York, 1997.