

Expert Systems: Commercializing Artificial Intelligence

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As this issue goes to press, news and discussion surrounding the commercial use of artificial intelligence (AI) by large technology firms—particularly machine learning and especially in the United States and China—are daily occurrences. Thoroughly commercial AI is placed at the center of discussions about geopolitics, military affairs, finance, labor, health, and art. This Special Issue of the *Annals* began with the observation that today's commercial AI, and breathless discussions about its future implications, has a history. Starting in the 1970s, a very different form of AI from today's machine learning developed and gained great attention: expert systems. Expert systems used logical reasoning to draw conclusions based on large sets of "If, Then" rules, engineered to represent the knowledge of domain experts. The 1980s witnessed a wave of commercialization of expert systems, by startups, by private sector firms, and by the U.S. military and its contractors. Throughout the decade, and accompanying this commercialization wave, scientists, engineers, and commentators put forward sweeping views of the importance of commercial expert systems for industry, the military, and culture. Despite the importance of the commercialization of expert systems to the history of AI, and its clear resonances with our present moment, this history was underdocumented and underexamined. (For more on this perspective, see David C. Brock's, "Learning from artificial intelligence's previous awakenings: The history of expert systems," *AI Magazine*, vol. 39, no. 3, pp. 3–15, Fall 2018.)

In May 2018, the Software Industry Special Interest Group (SI SIG) and the Software History Center of the Computer History Museum (CHM) conducted a two-day meeting for 20 of the pioneers who had formed expert systems companies or led the research and development work in expert systems during the 1970–2000 period. In addition, several computer historians and other representatives from CHM and SI SIG participated.

In conjunction with each meeting, several oral histories were also conducted to further enrich the sources for historians and researchers. This meeting was moderated by David C. Brock and Burt Grad, the guest coeditors of this Special Issue of the *Annals*.

This continued a 20-year effort by SI SIG in collaboration with CHM and the Charles Babbage Institute to collect the first-hand recollections of software industry pioneers regarding the companies they had formed and grown in the 20th century. It was the 13th of these pioneer meetings, each of which has been video recorded and the transcripts of the workshops have been edited and posted on the CHM website.

This issue includes two articles from historians, Hallam Stevens and Shreeharsh Kelkar. Stevens details the early commercialization of expert systems in molecular biology and biotechnology, while Kelkar examines the history behind software systems for instructing and tutoring students, so-called "edtech." Paul Harmon, who edited a leading expert systems industry newsletter, provides an overview of the industry, structuring how different companies addressed the potential market opportunities. The next three articles are by company founders who tell the story of their own background in AI and how they were able to start expert systems companies, what markets they addressed, and how their companies fared over the next 10–20 years. They also describe their own experiences afterward. These authors are Doug Lenat (MCC/CyCorp), Peter Hart (Syntelligence), and Monte Zweben (Red Pepper/Blue Martini). Reid Smith covers the wide range of expert systems and other AI technologies that were used by Schlumberger to enhance their work in fossil fuel exploration.

Following these articles is an anecdote by Fritz Kunze who talks about forming Franz, Inc., which was a long-lived company, following a quite different path from the companies formed by Stanford University Ph.D.s. To complete the issue, there is an edited oral history of Peter Friedland (interviewed by David Grier) who helped form and run IntelliCorp (which later spawned Teknowledge), and a biography of Edward Feigenbaum by Pamela McCorduck, who has sadly died since writing this biography. Ed Feigenbaum is

recognized as one of the most central figures in the history of expert systems.

We feel very privileged to have been able to attract so many of the key players in expert systems to attend the pioneer meeting and then to be willing to write their stories for this Special Issue. Our thanks go to David Hemmendinger and Dave Walden for encouraging us to proceed and to the reviewers who provided such outstanding feedback, which improved the quality and scope of many of the articles. Thanks to Gerardo Con Diaz, the department editors, and the IEEE staff who have helped to make this such a comprehensive Special Issue.

EXPERT SYSTEMS PIONEER MEETING

The May 2018 AI: Expert Systems pioneer meeting covered in broad strokes the history of the technology underlying AI in the 1950s and 1960s and the businesses that were founded during the 1970s and 1980s using expert systems technologies. While the initial work was pursued in several universities, including MIT and Carnegie Mellon, many of the companies were developed as a result of work done at Stanford University by Edward Feigenbaum and the large number of graduate students and postdocs who went to Stanford to be a part of this evolving area.

A substantial number of companies were formed, and many of their stories were covered during the meeting, including how they were founded, both from a technology and financial standpoint, and how they handled clients and marketing. The work sessions also explored why most of the companies did not grow significantly and why this industry area ended somewhat abruptly. Later sessions explored how the technology is still widely used by companies throughout the world. Finally, the attendees talked about the future of AI and how it has become such a vital growth area, essentially a key technology in virtually every major business in the 2000s and the backbone of some of the largest revenue and stock valued companies in the world.

Following are brief descriptions of the workshop sessions that were conducted.

- 1) **Session 1—Purpose/Structure & Introductions:** Meeting objectives and process: Each participant gave a brief statement about their experiences in the subject area.
- 2) **Session 2—AI Science & Technology 1955 to 1965:** AI science and technology—learning machines, neural networks, pattern recognition,

heuristic search programs, natural language processing using semantics, symbolic manipulation languages (IPL, Lisp, Snobol), initial work on game playing programs (checkers, chess), and decision logic projects.

- 3) **Session 3—Expert Systems Science & Technology 1965 to 1980:** Cognitive and knowledge-based systems science and technology—Capturing expert knowledge and reasoning. Representing this knowledge base using decision rules and other formulations. Prolog language; the development of Lisp machines. Acquiring the knowledge bases and constructing the inference engines to solve problems in medicine, engineering, and business. Stanford, MIT, Carnegie Mellon, and national research communities (e.g., AI in medicine).
- 4) **Session 4—Business Reviews for Initial Companies:** Machine Intelligence; Intelligenetics/Intellincorp; Inference; Advanced Decision Systems; AI Corp; Carnegie Group, Symantec; Teknowledge; MCC.
- 5) **Session 5—Business Reviews for Later Companies:** CyCorp; Syntelligence; Neuron Data; Franze, Inc.; Aion/Trinzic; IBM; Schlumberger.
- 6) **Session 6—Expert Systems Applications:** This session asked the attendees to describe actual scientific/technically oriented and business and commercially oriented expert systems applications with which they were familiar. We focused on what problems were being attacked, the methodologies used to capture the knowledge base, and the means used so that computers could be used with that knowledge base to help solve the problems being addressed
- 7) **Session 7—Why did the Expert Systems Industry Decline?** What were the factors that led to the demise of most of the expert systems companies? What strategies were used to keep some of the companies going? What expert systems companies are still operating and if so, what are they doing?
- 8) **Session 8—Artificial Intelligence and Machine Learning in the 1990s:** How has the interest in the technologies and businesses of expert systems and knowledge-based systems developed to the present day? In what ways is the story of machine learning connected to the story of expert systems? What do the meeting participants make of the development of machine learning: its applications in business? What do the meeting participants see moving ahead?

The following companies/organizations were represented at the meeting:

- › Advanced Decision Systems—Brian McCune
- › Aldo—Avron Barr
- › Carnegie Group—Mark Fox
- › Expert Systems Newsletter—Paul Harmon
- › Franze, Inc.—Fritz Kunze
- › Google—Peter Norvig
- › IBM—Herb Schorr
- › Inference—Brad Allen
- › Intelligenetics/Intellicorp—Peter Friedland
- › MCC/CyCorp—Douglas Lenat
- › Microsoft—Eric Horvitz
- › Neuron Data—Alain Rappaport
- › Red Pepper/Blue Martini—Monte Zweben
- › Schlumberger—Reid Smith
- › Stanford University—Edward Feigenbaum
- › Symantec—Gary Hendrix
- › Syntelligence—Peter Hart
- › Teknowledge—Dennis Brown

In addition to the expert systems industry attendees, the following historians participated:

- › David Brock, Director, Software History Center, CHM
- › Stephanie Dick, University of Pennsylvania
- › Colin Garvey, Rensselaer Polytechnic Institute
- › David Grier, George Washington University
- › Thomas Haigh, University of Wisconsin at Milwaukee
- › David Hemmendinger, Associate Editor-in-Chief, *IEEE Annals of the History of Computing*
- › Hansen Hsu, Historian, Software History Center, CHM

The sessions were all video recorded and have been transcribed and posted on the CHM website (www.computerhistory.org). Oral histories conducted with some of the participants are also posted on the CHM website.

DAVID C. BROCK is currently the Director of Curatorial Affairs for the Computer History Museum, Mountain View, CA, USA, and an historian of technology. He is also the biographies editor for the *IEEE Annals*. He is the co-author of *Moore's Law: The Biography of Gordon Moore, Silicon Valley's Quiet*

Revolutionary (Basic Books, 2015) and *Makers of the Microchip: A Documentary History of Fairchild Semiconductor* (MIT Press, 2010). Contact him at dbrock@computerhistory.org.

BURT GRAD has been in the computer software arena since he worked on the Univac I at General Electric in the 1950s. He was with GE until 1960, and then with IBM until 1978, becoming the director of development after being part of the IBM unbundling team for software and services in 1969. As IBM's representative to ADAPSO's software section starting in 1970, he became an active organizer of meetings and special projects. He became friends with many of the entrepreneurs who were starting software companies. Leaving IBM in 1978, he started Burton Grad Associates, Inc. (BGAI), which was a boutique consulting firm for software and services companies. BGAI served more than 200 clients over the next 28 years. He partnered with Luanne Johnson to start and run the Software Industry SIG, Computer History Museum, Mountain View, CA, USA, from 2000 to 2022. Contact him at burtgrad@aol.com.

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