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In Memoriam

Arthur Samuel: Pioneer in Machine Learning

Arthur Samuel (1901–1990) was a pioneer of artificial intelligence research. From 1949 through the late 1960s, he did the best work in making computers learn from their experience. His vehicle for this work was the game of checkers.

Programs for playing games often fill the role in artificial intelligence research that the fruit fly Drosophila plays in genetics. Drosophilae are convenient for genetics because they breed fast and are cheap to keep, and games are convenient for artificial intelligence because it is easy to compare a computer's performance on games with that of a person.

Samuel also took advantage of the fact that checker players have many volumes of annotated games, with the good moves distinguished from the bad ones. Samuel's learning program used Lee's *Guide to Checkers* to adjust its criteria for choosing moves, so that the program would choose those moves thought good by checker experts as often as possible.

In 1961, when Ed Feigenbaum and Julian Feldman were putting together the first AI anthology, *Computers and Thought,* they asked Samuel to include the best game the program had ever played as an appendix to his splendid paper on the checker player. Samuel used this request as an opportunity to challenge the Connecticut state checker champion, who was ranked number four in the nation. Samuel's program won. The champion provided annotation and commentary to the game when it was included in the anthology.

As one of the earliest examples of nonnumeric computation, Samuel's checker work greatly influenced the instruction set of early IBM computers. The logical instructions of these computers were put in at his instigation and were quickly adopted by all computer designers because they are useful for most nonnumeric computation.

Samuel was a modest man, and the importance of his work was widely recognized only after his retirement from IBM in 1966, in part because he didn't relish the politics that were required to have his research more vigorously followed up on. He was also realistic about the large difference between what had been accomplished in understanding intellectual mechanisms and what would be required to reach human-level intelligence.

Samuel's papers on machine learning are still worth studying. Possessing great creativity and essentially working alone, doing his own programming, he invented several seminal techniques in rote learning and generalization learning, using such underlying techniques as mutable evaluation functions, hill climbing, and signature tables. One still hears proposals for research in this area that are less sophisticated than Samuel's work of the 1950s.

Before his machine learning work, Samuel had a distinguished career as an electrical engineer and also as an engineer at IBM. In addition, he was a manager of research in engineering and science. He graduated from Emporia College in 1923. Receiving a Master's degree from the Massachusetts Institute of Technology in 1926, he stayed on as an instructor in electrical engineering until 1928, when he joined Bell Telephone Laboratories. At Bell Labs, he worked mainly on electron tubes. Particularly notable was his work on space charge between parallel electrodes and his wartime work on TR-boxes (a switch that disconnects the receiver of a radar when the radar is transmitting and prevents the sensitive receiver from being destroyed by the high-power transmitter).

In 1946, Samuel became a professor of electrical engineering at the University of Illinois. He was actively involved in the project to design one of the first electronic computers. It was here that he conceived the idea of a checker program that could beat the world champion and demonstrate the power of electronic computers. He didn't finish the program while he was at the university of Illinois, perhaps because the computer wasn't finished in time.

In 1949, Samuel joined IBM's Poughkeepsie Laboratory, where he worked on IBM's first stored program computer, the 701. This computer's memory was based on Williams tubes, which stored bits as charged spots on the screen of a cathode ray tube. Samuel managed to increase the number of bits stored from the customary 512 to 2048 and to raise the mean time to failure to half an hour.

He completed the first checker program on the 701, and when it was about to be demonstrated, Thomas J. Watson, Sr., the founder and president of IBM, remarked that the demonstration would raise the price of IBM stock by 15 points. It did.

Besides engineering and computer science, Samuel was important for his management work. He played a large role in establishing IBM's European laboratories and setting their research directions, especially in Vienna and Zurich. The Vienna Laboratory was recognized for its work in computer science and the Zurich laboratory for its work in physics.

Samuel retired from IBM in 1966 and came to Stanford University as a research professor. At Stanford, he continued his work on checkers until his program was outclassed in the 1970s. He also worked on speech recognition until the Defense Advanced Research Projects Agency decided to concentrate its speech work on one approach. He supervised several Ph.D. theses while at Stanford.

Samuel's other talents included understanding inadequate documentation of complicated programs and writing clear and attractive manuals. His *First Grade Tex* was recently translated into Japanese.

As a person, Samuel was distinguished by his objectivity and his kindness in helping many people, especially in learning about the many matters in which he was an expert.

Samuel remained an active computer programmer long after age forced him to give up active research. His last work, continued until he was past the age of 85, involved modifying programs for printing in multiple-type fonts on some of the Stanford Computer Science Department's computers. Parkinson's disease finally forced him to stop active work. We believe he was the world's oldest active computer programmer. The computer he used tells us that he last logged into it on February 2, 1990.

Samuel was a fellow of the Institute of Electrical and Electronic Engineers, the American Physical Society, the Institute of Radio Engineers, and the American Institute of Electrical Engineers and was a member of the Association for Computing Machinery and the American Association for the Advancement of Science.

He is survived by a brother, two daughters, and four grandchildren. The family requests that donations be sent to the Arthur L. Samuel Fellowship Fund, a special Stanford scholarship established in his honor. Contributions can be sent to Carolyn Tajnai, Assistant Chairman of the Computer Science Department, Stanford University, Stanford, CA 94305.

—John McCarthy and Ed Feigenbaum

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