

1917 Karl Steinbuch 2005

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Karl Steinbuch, a pioneer of artificial neural networks and the father of German Computer Science, passed away on 4 June 2005, a few days before his 88th birthday (18 June). Like Konrad Zuse (who developed a functioning program-controlled computing machine c.1936), Steinbuch has been largely unknown outside Germany, but is a celebrated computer pioneer in his native land. Steinbuch was a member of the German Academy of Natural Scientists Leopoldina (founded in 1652) and the International Academy of Science and received numerous awards, including the Wilhelm Boelsche Gold Medal, the German Non-Fiction Book Award, the Gold Medal of the 21st International Conference of Aviation & Space Medicine, the Konrad Adenauer Science Award, the Jakob Fugger Medal, and the Prime Minister's Merit Medal of the German State of Baden-Wuerttemberg, and many more. Baden-Wuerttemberg sponsors several "Karl Steinbuch scholarships" each year.

More than a decade before the first CS department was founded in Germany (the Fakultät fuer Informatik at University of Karlsruhe in 1969) Steinbuch gave regularly scheduled academic courses on CS and coined the term "Informatik" [1], which became the German term for Computer Science. Co-author Reiner Hartenstein was one of Steinbuch's first graduate students at Karlsruhe's EE department in 1958. He reflects that Steinbuch was a giant, far ahead of his time in several areas.

In 1966 Steinbuch predicted the multimedia age by merging computers, communication and entertainment electron-

ics. He was a talented educator and book writer, who frequently, and effectively, addressed a wide non-engineering audience. His books "Falsch programmiert" [2] (which could be translated as "the wrong roadmap") and "Programm 2000" [3] were listed for several months on the weekly top 20 best-seller list of DER SPIEGEL (the German TIMES). In these books, criticizing the German research and education policy, Steinbuch predicted ("by the turn of the century") the current German structural economic crisis, i.e. already 30 years in advance.

Steinbuch held 80 patents. Before joining the University of Karlsruhe, Karl Steinbuch was director of development at the Stuttgart "Informatik-Werk" of Standard Electric Lorenz AG (SEL); at that time a part of the ITT group. In 1954 he became a strong advocate of the use of transistors instead of vacuum tubes for digital computer product development (this was before silicon transistors became available). Under his leadership, development of the ER-56, Europe's first fully transistorized digital computer, was completed, and then marketed as a product by SEL. The ER-56 exhibited a dramatic increase in reliability over vacuum tube computers (which typically spent more than 50% of their time in maintenance). As Steinbuch's graduate student at Karlsruhe, co-author Reiner Hartenstein was a user of an ER-56, which, in its initial configuration, had a very small primary memory (since each bit had to be built out of a discrete-transistor-implemented flip-flop circuit).

In 1961 Karl Steinbuch published a paper on the "Lernmatrix," a novel associative memory artificial neural network (ANN). This was followed by the world's first monograph on neural networks *Automat und Mensch* (Machine and Man) [4], which was revised and expanded three times [5,6,7]. Because it was published in German, Steinbuch's Lernmatrix work did not immediately become widely known. However, this was partially remedied with an English publication [8]. Nonetheless, in Germany there has been a strong and persistent feeling that Steinbuch was never afforded adequate attention by the world at large [9] ("Karl Steinbuch, an unjustly forgotten Pioneer of Artificial Neural Systems").

Co-author Bernard Widrow, originator of the ADALINE artificial neural network [10] became aware of Steinbuch's Lernmatrix work shortly after its initial publication. Intrigued by this radically different approach to neural computation, Widrow invited Steinbuch to visit

Stanford University in 1964 and carry out a comparative study of their architectures. This visit yielded both a friendship and a joint paper summarizing their conclusions [11]. Widrow also fondly remembers a 1967 family visit to the Steinbuch home in Germany. During this visit, the Widrow children and the Steinbuch children greatly enjoyed playing together; and Mrs. Steinbuch prepared a delicious celebratory dinner. The children's English and German all mixed together; which was no problem, since kids really speak Kid Language. Widrow recalls: "We had a wonderful visit at Karlsruhe, and the friendship and kindness of the Steinbuchs will always be remembered."

Meeting Karl Steinbuch for the first time in the early 1990's, co-author Robert Hecht-Nielsen asked him about how he came to invent the Lernmatrix. Steinbuch stated that the experience of watching his children learn instilled within him an intense desire to understand the mechanisms of learning and thinking. As with Hebb a decade earlier, Steinbuch sensed that the answers would be relatively simple mathematically; but probably exotically alien in comparison with existing scientific, mathematical, and technological concepts. As later developments based on Steinbuch's Lernmatrix have shown [12,13], Steinbuch's vision was likely correct.

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