OBITUARY

Gene H. Golub (1932–2007)

Mathematician and godfather of numerical analysis.

A century ago, matrices and the techniques for their manipulation — linear algebra — were a backwater of mathematics. Today, they are the foundation not just of the mathematical field of numerical analysis, but also of computational science and engineering, and have become indispensable for anyone who wants to get numerical results from a computer. The pre-eminent figure in matrix computations over the past 50 years, Gene Golub, died on 16 November.

Golub was born in Chicago on 29 February 1932, to Jewish parents from Latvia and the Ukraine. His childhood was not affluent, but he was a good student. After two years at a junior college, he transferred to the University of Illinois at Urbana-Champaign, achieving his doctorate there in 1959. At the time, Illinois, with the first of its 'ILLIAC' supercomputers, was a great centre of computing, and Golub showed his affection for his Alma Mater by endowing a chair there 50 years later. Rumour has it that the funds for the gift came from Google stock acquired in exchange for some advice on linear algebra. Google's PageRank search technology starts from a matrix computation — an eigenvalue problem with dimensions in the billions. Hardly surprising, Golub would have said: everything is linear algebra.

He came to believe that in his twenties, as he realized that new methods of orthogonal-matrix factorization introduced by Wallace Givens and Alston Householder offered the right mathematical recipe for solving all kinds of problems. In particular, Golub focused on the idea known as singular value decomposition, SVD, which systematically isolates the dominant components of a linear process. Together with William Kahan and Christian Reinsch, he invented the now-standard SVD algorithms, and showed scientists, engineers and statisticians how these algorithms could be used in areas such as the least-squares method to find the best fit to a curve; in optimization problems and control theory; and for the determination of crucial matrix parameters such as their norms, ranks and condition numbers. In later years he drove a car with the licence plate 'PROF SVD'.

Golub found his way to Stanford University in 1962, eventually becoming the senior professor in its formidable computer science department. In 45 productive years there, he advanced matrix computations in areas as diverse as geodesy, data mining and quantum chromodynamics. The dimension of what was considered a 'big' matrix grew from 100 to 1,000,000 in the same period, and Golub was among the first to develop the iterative algorithms that make problems involving such huge matrices tractable.

As the new methods came in, older ideas such as gaussian elimination (essentially, the way one is taught to solve a system of simultaneous equations in school, by eliminating the variables one by one) became a smaller part of a new and greater enterprise. Along with the new algorithms came a new world of software for solving mathematical problems, such as EISPACK, LAPACK and MATLAB. Golub's book *Matrix Computations*, co-authored with Charles Van Loan of Cornell University, became a bestseller and the definitive textbook of the field. Honours flowed in, including membership of the US National Academies.

As a servant of the wider scientific community, Golub did as much as anybody to make the Society for Industrial and Applied Mathematics (SIAM) the organization it is today. He served it in various capacities, among them as president (1985–87). He also founded and edited two of the society's journals, the *SIAM Journal on Scientific and Statistical Computing* and *SIAM Journal on Matrix Analysis and Applications*. It was his proposal that led to the quadrennial International Congresses on Industrial and Applied Mathematics.

But this impressive list of achievements misses the truly extraordinary aspect of this complex man: the scale of his devotion to people. Golub was a bachelor for most of his life, and his colleagues were his family. No family ever had a more loving, attentive or exasperating father. As he liked to say, "Every numerical analyst has a second home at Stanford". Countless colleagues enjoyed a glass of wine at his home there, and hundreds of them stayed over for a night or even a month at his invitation. How did he remember all our birthdays and reading tastes and children's names?

Golub could not spend a day without other people. He would eat dinner with them, talk matrices with them, organize conferences with them, write papers and books with them, argue academic politics with them — an endless dance of interactions, plans and projects. Anywhere in the world, a numerical analyst knows who is meant by 'Gene'. About 250 of them were his co-authors. They knew that it would fall to them to do most of the writing; but Golub saw the connections, knew the literature, and made the paper happen.

He seemed almost to have invented e-mail. As early as 1981, his office computer was set up to beep the moment a message arrived. His personal address list evolved into the worldwide database of numerical analysts, and his notes to friends became the Numerical Analysis Digest. This newsletter, one of the first e-bulletins, is now sent to some 8,000 recipients weekly. He could not sit still. As he left us in Oxford last September after an extended sabbatical visit, having spent much of the preceding months talking with the graduate students in the common room — to which he had donated $1,000 for a biscuit fund — he mentioned that he had three trips to China planned for the upcoming year.

Gene Golub was restless and never entirely happy. He was a demanding friend; behind his back, we all had Gene stories to tell. It was a huge back: Gene was big, dominating any room he was in, and grew more impressive and imposing with the years. Graduate students around the world admired and loved him, and he bought them all dinner when he got the chance. His unexpected death, in Stanford in between speaking at a conference in Hong Kong and flying to Zurich for his eleventh honorary degree, has left the world of numerical analysis orphaned and reverberating.

Lloyd N. Trefethen

Lloyd N. Trefethen is in the Oxford University Computing Laboratory, Oxford OX1 3QD, UK.
e-mail: lnt@comlab.ox.ac.uk