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Personal report

Gene Howard Golub, 1932–2007

Gene Golub [29].

"I always thought Gene was immortal!"

Pete Stewart's reaction [30] on hearing of Gene Golub's illness reflects what many of us felt. In numerous ways, Gene seemed larger than life, and it is difficult to imagine the computational linear algebra community without him.

Gene was born in Chicago, Illinois on Leap Day, 29 February 1932, and died at Stanford on 16 November 2007, shortly after being diagnosed with acute myeloid leukemia. He received his bachelor's, master's, and Ph.D. degrees from the University of Illinois and took a National Science Foundation postdoctoral fellowship at Cambridge. After short-term positions at Lawrence Radiation Laboratory and Space Technology Laboratories, he arrived at Stanford in 1962 and became a founding member of the Computer Science Department in 1965. He remained on the faculty at Stanford throughout the rest of his career, rising through the ranks while the department was under the direction of George Forsythe. When Forsythe died in 1972, Gene was left with 14 graduate students and an important legacy.

Stanford, especially the Serra House building where the numerical group resided, was already a research center for computational linear algebra. Illustrious faculty, a great number of bright,

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energetic students, and a steady stream of visitors (long- and short-term, famous and still unknown), made it a hub of activity. Many collaborations and many life-long friendships had their beginnings there. Gene continued Forsythe's tradition, and the tradition Gene had experienced at Illinois, setting a tone of hospitality at Serra House ("SVD Headquarters") and at his own home. He aided the careers of many who needed extra help, whether they were young people or mathematicians from nations in South America, Eastern Europe, or Asia, where opportunities were fewer. He was also a remarkable mentor for women, providing support while promoting independence. He never forgot that he himself, coming from an immigrant family, born during the Great Depression, with a "bread man" and a seamstress as parents, was a rather unlikely candidate for success as a mathematician, so he always encouraged mathematical talent to flourish despite handicaps.

Gene became the Fletcher Jones Professor of Computer Science at Stanford University. He chaired the Computer Science Department at Stanford (1981–1984) and developed the Scientific Computing and Computational Mathematics Program at Stanford (1988), one of the first graduate programs in the field. He served as president of SIAM (1985–1987) and founding editor of *SIAM Journal on Scientific and Statistical Computing* (1980) and *SIAM Journal on Matrix Analysis and Applications* (1988).

Gene's scientific achievements transformed the field of matrix computations. Through over 175 journal articles, he showed remarkable breadth, creativity, and productivity, contributing fundamental computational algorithms and broadening the applications of matrix methods.

His most famous achievements are associated with the singular value decomposition (SVD), the "Swiss Army knife" of matrix decompositions. He developed the computational algorithms for computing the SVD, both the direct algorithm (by describing Householder reduction to bidiagonal form with Kahan [17, pp. 208–210] and computation of the singular values of the bidiagonal matrix with Reinsch [21, Section 1.3]) and the iterative one for large sparse systems (by proposing a Lanczos-type reduction to bidiagonal form with Kahan [17, pp. 210–211]). Much of his later work showed how the SVD could be used to solve a remarkable array of problems, from total least squares [24] to computing angles between subspaces [3]. The 67,000 papers listed on Google Scholar that use the SVD demonstrate how much just this one small piece of his work has influenced computation in science and engineering.

But his influence goes far beyond the SVD. His introduction of numerically stable methods into linear programming computations [2]; his critical role in popularizing the use of matrix splittings [1,26], preconditioned conjugate gradients, and related algorithms [7,8]; his beautiful work on updating eigenvalues [15] and matrix factorizations [13]; and his deep insight into the relation between matrix moments [19], orthogonal polynomials [11], conjugate gradients, and Gauss quadrature [5,18,27] are just a few of his major achievements. The Chebyshev semi-iterative method for solving linear systems inspired papers from his thesis [25] to much later work [12]. His algorithmic work on linear least squares problems [14], separable nonlinear least squares problems [20], and fast Poisson solvers [4] proved extraordinarily useful in applications. His contributions to the solution of ill-posed problems included the analysis of generalized cross-validation for choosing regularization parameters [16]. His work also contributed major insights into the matrix eigenvalue problem [3,22,28] and the inverse eigenvalue problem [9]. He ranked all of these papers among his favorites, and chose 21 of them to be included in a selected works volume [6] prepared in 2007 on the occasion of his 75th birthday.

Another part of Gene's legacy is his transformational book with Charlie Van Loan [23]. This book (they were working on the 4th edition) made a powerful body of algorithms and theorems accessible to mathematicians and non-mathematicians, and it alone has over 15,000 Google Scholar citations.

Gene was not a flashy classroom teacher, but the joy and excitement in his voice when teaching about a favorite algorithm or theorem was infectious. Students instinctively understood that he taught with authority and great insight.

Gene loved to travel. Just two weeks before his death, he returned from a trip to Hong Kong, and he had been scheduled to travel to Zürich (to receive his 11th honorary degree) the week he died. He reached out to scientists and engineers and made the effort to overcome barriers of jargon and ossified attitudes in order to transform matrix computation in many fields. He seemed to view his role as prophetic rather than didactic, traveling the world on a mission to tell mathematicians and computational scientists to abandon inefficient and unstable matrix methods and take up state-of-the-art algorithms.

Gene had a wide range of interests, but he thought about mathematics at every conceivable and inconceivable opportunity. A new idea or problem never failed to bring him excitement. His wide circle of friends and his broad knowledge of research made him an excellent collaborator as well as a catalyst for scientific collaborations among others. He also brought the community together through innovations like NA-Net (an on-line directory of numerical analysts) and NA-Digest (a weekly email news bulletin) [10].

Gene was greathearted. Quiet good deeds, whether looking after colleagues' children when they were far from home or paying the tuition of a student in need, were routine for him. He adopted the entire computational linear algebra community as his family. (In his view the family did, of course, include some black sheep.) He was never happier than when surrounded by people he had brought together, and the entire field was much closer because of him.

Some great mathematicians are pompous and inaccessible, but Gene was gregarious and especially kind to newcomers in the field. He was often insecure, sometimes difficult, never dull, and always principled. He taught his students not only how to do scientific research, but also how a scientist should behave, and we were deeply grateful for having him as a mentor. By word and deed he showed us that we need to give back to the field by taking leadership in professional organizations, refereeing, mentoring, organizing conferences, preserving the history of our field, and taking on other professional duties. He was elected to membership in the Royal Swedish Academy of Engineering Sciences (1986), the National Academy of Engineering (1990), the National Academy of Sciences (1993), the American Academy of Arts and Sciences (1994), and the Hall of Fame for Engineering, Science and Technology (2002). Of all his achievements, though, I think he was most proud of his 30 Ph.D. students, and, of course, of their students, too.

It was easy to think that Gene was immortal. Despite his death, his life's work of contributions to matrix computations, scientific computing education, mentoring, and service to the profession is a lasting legacy.

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