

## Back to the roots: Multivariate polynomial optimization by numerical linear algebra

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### Abstract

Finding some or all of the roots of a set of multivariate polynomials has numerous applications. This century old problem is at the foundation of *algebraic geometry* sometimes called the ‘queen of mathematics’. In this discipline, typically, numerical computations are done *symbolically*, and only quite recently, it was realized that the multivariate polynomial rooting problem can be tackled using the machinery of *numerical linear algebra*, because of the fundamental insight that it is equivalent to an eigenvalue problem. In order to find some or all roots, we deploy tools like the QR- and singular value decomposition, and (possibly large scale) iterative eigenvalue solvers. We will discuss several eigenvalue decomposition based algorithms to calculate the global minimum of multivariate polynomial optimization problems. We will illustrate our approach with the numerical solution of two open problems in system theory: Calculating from (noisy) data linear dynamic models that are least squares optimal, and finding the least squares global optimum of the H2 model reduction problem.



**Prof. Dr. Bart De Moor** received his MS (1983) and PhD (1988) degrees from the KU Leuven, Belgium, in electrical engineering (control theory). He is a full professor at the department of Electrical Engineering (ESAT-STADIUS) of KU Leuven, where he also holds the ‘CM Health Insurance’ endowed chair in ‘Health Care Systems Quality and Accessibility’. He is a guest professor at the University of Siena, Italy. He was visiting research associate at Stanford University (1988-1991). Between 1991-2007, he was the chief advisor on science and technology and head of cabinet of several federal and regional ministers. He was vice-rector of International Policy of KU Leuven (2009-2013) and head of its Industrial Research Fund (2006-2015). He has published more than 400 scientific journal papers, 450 conference papers, eleven books, and numerous science popularizing contributions. Currently, he is the promoter of 10 PhD students and 4 postdocs and 82 PhDs were obtained under his guidance. His research interests are in numerical linear algebra and algebraic geometry, dynamical systems theory and identification, advanced control theory, machine/deep learning, bioinformatics, digital health and clinical genomics. Dr. De Moor received the Leybold-Heraeus Prize (1986), the Leslie Fox Prize (1989), the Guillemin-Cauer Best Paper Award of the IEEE Transactions on Circuits and Systems (1990), the Laureate of the Belgian Royal Academy of Sciences (1992), the bi-annual Siemens Award (1994), the Best Paper Award of Automatica (IFAC, 1996), the IEEE Signal Processing Society Best Paper Award (1999) and the excellence award of the Flanders Research Foundation (2010) from King Albert II of Belgium. He became fellow of IEEE (2003) and SIAM (2017) and is a member of the Belgian Royal Academy. He co-founded or contributed to 8 spin-off companies, 7 of which are still active or had a successful exit (IPCOS, Data4S, Transport & Mobility Leuven, Trendminer, Cartagena, Ugentec, Lindacare). He is chair or board member in several cultural, scientific and funding organizations, and member of numerous scientific assessment committees worldwide. Full details on his CV can be found at [www.bartdemoor.be](http://www.bartdemoor.be).