Professional Feature - Lieven De Lathauwer

By **Invited Professional Contribution**
Print

When I had to choose a field of study at university, I was torn between engineering and medicine. Engineering appealed to me at the bachelor's level because of its emphasis on basic sciences. I had always been good at mathematics and I found it enjoyable when there was no pressure. However, I was concerned about the more technical courses that would be prevalent at the master's level. I also lacked role models in engineering, except for a talented uncle who ran a small high-tech company specializing in hydraulics, which wasn't really my thing. Medicine, on the other hand, appealed to my sense of moral duty. However, I was worried about the amount of memorization required. Ultimately, I decided to pursue engineering with the plan of continuing with postgraduate studies in biomedical engineering after completing my master's degree.

My favorite undergraduate course was applied linear algebra. I was fascinated by the "architectural beauty" of the subject. There was much to explore and little to memorize. In later years, I enjoyed courses in a similar vein, such as systems and control, digital signal processing, and pattern recognition.

Our physics professor in the second year of my bachelor's program made a brief comment at one point that the theory of relativity makes use of "higher-order tensors," a multi-way extension of matrices. I began to wonder about higher-order extensions of the basic linear algebra course, which undoubtedly would also have many applications. After completing my master's thesis, which was on a problem in biomedical signal processing, I went to see my former algebra professor, Joos Vandewalle, and proposed pursuing a Ph.D. on tensor extensions of linear algebra and their applications.

This next step made complete sense. In the research division I joined as a Ph.D. student, the Singular Value Decomposition (SVD) of matrices was a central theme. Several of my peers were investigating applications, computational aspects, and variants of the SVD. As a matter of fact, I became responsible for the practical organization of the third Workshop on SVD and Signal Processing, which took place at KU Leuven in 1995. In my research, I discovered that a result obtained by Tucker for multi-way data in psychometrics in the 1960s could be seen through the lens of the SVD and reinterpreted as a multilinear extension, opening up a whole range of mathematical connections and real-life applications.

It turned out I was the first person in SIAM to investigate such things, and among the very first in IEEE. At the time, higher-order statistics were a hot topic in signal processing. Higher-order statistics are in fact higher-order tensors, and some French colleagues had begun investigating tensor methods for blind source separation. Later on, I introduced the first biomedical application of such techniques, inspired by my master's thesis work, along with new algorithms for blind source separation.



Figure 1. *Slide presentation at NOLTA '95 as a Ph.D. student.*

I was very convinced of the importance of tensor methods. (If interested in the what and why, the reader might want to check [1] for a quick layman's introduction.) At signal processing conferences, my work was appreciated, but to my surprise, only a few others took the initiative to join the endeavor. Preoccupied with actual research, I didn't care much about publishing in journals as a Ph.D. student. The papers on multilinear SVD and on a multilinear extension of the power method/orthogonal iteration method appeared in SIMAX (only) in 2000. Somewhat later, in 2004, I was invited by Gene Golub from Stanford University (who had been the postdoc mentor of my Ph.D. co-supervisor, Bart De Moor) to a workshop on tensor methods. To my great surprise, several of the participants (typically with a SIAM background) knew me and had actually studied my Ph.D. thesis and papers. Participants at that workshop introduced tensor methods in disciplines as diverse as scientific computing, bioinformatics, and computer vision.

Around 2000, I was invited by Inbar Fijalkow to apply for a Research Associate position with the French Centre National de la Recherche Scientifique (CNRS), which led me to join her lab in Cergy-Pontoise, near Paris. We had met at workshops and conferences, and she was impressed by my work. I gratefully seized the opportunity and remained affiliated until 2007, when I had the chance to return to my home country, Belgium, and take a permanent position at KU Leuven (Kulak).

In line with my initial enthusiasm as a bachelor's/master's student for "linear algebra and applications," my research evolved into a broad-spectrum exploration of "multilinear algebra and applications." I deeply respect the profound insights obtained by colleagues at the mathematical end of this spectrum. Equally, I value the efforts of colleagues at the application end who "make things work" in a principled manner. In cross-disciplinary collaborations, I have noticed that sometimes subtle technical and cultural differences can pose challenges. (For instance, the presence or absence of noise can completely change a problem. It also makes a significant difference whether one needs to deal with measurement noise or numerical quantization noise.) Developing a common language and understanding is often half the work. Success tends to depend more on the people involved than on the subject matter.

My intellectual creativity was initially somewhat impeded by a certain lack of self-confidence. For strong research, both creativity and rigor need to be strong and in balance. A few people close to me made a big difference. In the professional context, I am very grateful to my colleague Sabine Van Huffel for

acknowledging the quality of my work at an early stage and offering me the opportunity to co-supervise a number of Ph.D. students as part of my career development. Years later, we co-supervised the highly successful ERC project BioTensors ("Biomedical Data Fusion using Tensor-based Blind Source Separation"). I also supported an ERC project of a colleague in materials engineering, Nele Moelans, where tensor completion enables thermodynamic modelling in high dimensions, each dimension corresponding to a different type of atom in a multicomponent alloy design.

I have been fortunate to work with some very talented individuals in my team. I must mention that Laurent Sorber and Nico Vervliet did an exceptional job in developing numerical algorithms and implementing them in Tensorlab (www.tensorlab.net). Ignat Domanov conducted a profound study on the uniqueness of tensor decompositions. Mikael Sorensen made significant contributions to constrained and coupled decompositions, as well as applications in array processing. Of course, there are many more people to mention and many more things to say.



Figure 2. *With current team members, from left to right: Raphaël Widdershoven, the author, Nithin Govindarajan, Shakir Showkat Sofi, Charlotte Vermeylen, Nico Vervliet.*

I have always had a very clear view of the scientific road ahead in the next, say, 10-20 years. Longer-term individual research goals often conflict with the shorter-term needs of one's professional environment. Over time, I started to feel frustration about the latter prevailing over the former, a problem I tended to fix by simply working harder. However, it is important to ensure that the balance is sustainable.

Over the years, I have experienced both high-integrity, quality-driven professional interactions and the opposite type of behavior (where belonging to a circle of friends is more important than doing valuable work). If the latter dynamics become widespread, they can destroy an entire society. In my experience, being true to oneself and doing the right thing is rewarding in the long run. To navigate difficult situations, it helps if this foundational attitude is manifested wisely.

My most fulfilling experiences have, somewhat to my own surprise, resulted from efforts for the benefit of others.

[1] Eric Evert, Lieven De Lathauwer, Tensors and multilinear algebra: what and why, Leuven.ai Stories, January 2023. Available online: https://ai.kuleuven.be/stories/post/2023-01-10-tensorlab/

Categories: Magazine, Articles
Tags:

Please login or register to post comments.