Department: In Memoriam

Tribute to Alfred Inselberg (1936–2019)

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Alfred "Al" Inselberg gave us the enduring idea of parallel coordinates for solving problems and visualizing data in multidimensional spaces. His bushy mustache, bright smile, and bear-like features were bigger than life, but sadly he died of cancer on December 30, 2019.

Inselberg charmed audiences with his fresh ideas delivered with playful flourishes, such as awarding question askers gifts of toothpicks or paperclips. When I first heard him speak at the University of Maryland in 1979, I was thrilled by his bold idea for visualizing more than three dimensions.

His advance over Rene Descartes's (1596–1650) three orthogonal axes to 4, 5, 6, or 50 parallel axes was so obvious and astonishing that my mind raced with the possibilities. However, it was a challenge to shift from thinking of a point in n-dimensions to a polyline across the n axes (see Figure 1). With each example, I gained fluency in seeing correlations, clusters, gaps, outliers, and anomalies. Inselberg polished the arguments for his parallel coordinates method, then built effective software, and demonstrated value in important applications.

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Alfred Inselberg in July 2004. (Photo by Ben Shneiderman; used with permission.)

Over the years, I met Inselberg a dozen times, posing new questions to understand the principles that he had already integrated into his thinking. He helped me overcome decades of perceptual training and cognitive expectations, so as to open my mind to a new way of seeing. Maybe younger minds that begin with parallel coordinates will be more fluent in seeing higher dimensional spaces more easily.

His stories of solving practical problems (gold market manipulation, detection of hostile vehicles, VLSI production, network failures, etc.) increased my confidence that his ideas were not only new, but also valuable. Just as Cartesian

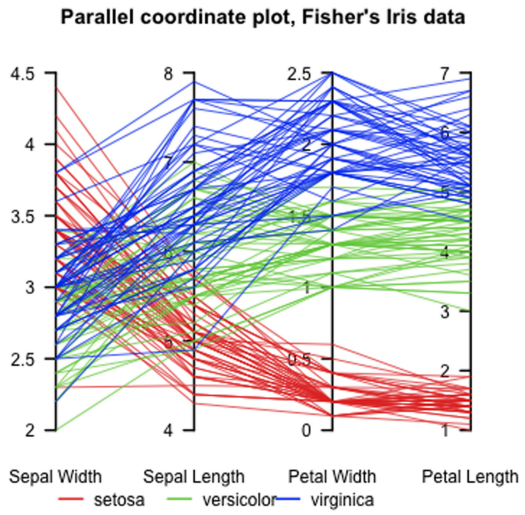

Figure 1. Parallel coordinates representation of Iris flower data showing three clusters across the four dimensions (From Wikimedia Foundation https://en.wikipedia.org/wiki/Parallel_coordinates).

coordinates help us understand 2-D and 3-D geometry, parallel coordinates offer fresh ways of thinking about and proving theorems in higher dimensional geometries. At the same time, they will lead to more powerful tools for solving practical problems in a wide variety of applications. It's rare to encounter such a mind-shattering idea that has such historic importance.

While Inselberg's insight opens the door to many discoveries, there is much work to be done for generations of master teachers, gifted mathematicians, inspired computer scientists, devoted programmers, and eager domain experts who will tame these wild ideas. Inselberg loved to tell stories of how his students had gone on to make contributions and breakthroughs that went beyond what he had accomplished.

My Foreword to Inselberg's 2009 book *Parallel Coordinates: Visual Multidimensional Geometry and Its Applications* (Springer, New York, NY, USA) said:

> *Parallel coordinates is one of the most significant breakthroughs in our field. It shows how information visualization can lead to deep mathematical insights that advance theory while enabling powerful practical solutions in multi-dimensional data. Parallel coordinates triggered a cascade of implementations for commercial and research visualization tools. Inselberg's remarkable stories of finding solutions to problems that stumped many others demonstrate not only the power of parallel coordinates, but his own astonishing capacity to apply them to solve key problems.*

Although there are precedents going back centuries, Inselberg's invention of parallel coordinates came in 1959. Then in 1977, while teaching a course in Linear Algebra, he made important refinements. Inselberg presented parallel coordinates at the 1980 Pattern Analysis and Machine Intelligence (PAMI) conference, (now called Computer Vision and Pattern Recognition), where the enthusiastic reception encouraged him further. In 1982, Stephen Hawking attended his lectures in Cambridge, urging Inselberg to continue this "exciting and important work."

Robert Kosara's widely read blog on information visualization writes:

> *Parallel coordinates are one of the most famous visualization techniques, and among the most common subjects of academic papers in visualization. While initially confusing, they are a very powerful tool for understanding multi-dimensional numerical datasets.*

In 1985, Inselberg's widely cited paper "The Plane with Parallel Coordinates" appeared in the first issue of *Visual Computer*, but its citation peak occurred in 2013, showing the growing appreciation of his contribution. While the basic idea of parallel coordinates is easy to understand, its deep implications take time to absorb, but the effort is worth it. Numerous implementations of parallel coordinates have been made, including our research version in the *Hierarchical Clustering Explorer* (www.cs.umd.edu/hcil/hce). Widely used commercial applications such as TIBCO's Spotfire and Microsoft's Power BI as well as the open source R and D3 toolkits include parallel coordinates.

Born in Athens in 1936, Inselberg was an exceptional high school student in Brighton, U.K., then moved to the University of Illinois in Champaign-Urbana for 12 years till he got his Ph.D. in mathematics in 1965. He eventually became a researcher at the IBM Scientific Center in Los Angeles and also taught at UCLA. In the 1980s, there was a fierce competition to receive the multibillion contract for the new Air Traffic Control system. By

ADDITIONAL RESOURCES:

- University of Illinois, Alfred Inselberg, 1936-2019: A life full circle (February 17, 2020)
  https://aerospace.illinois.edu/news/alfred-inselberg-1936-2019-life-full-circle

Wikipedia
https://en.wikipedia.org/wiki/Alfred_Inselberg
https://en.wikipedia.org/wiki/Parallel_coordinates

Al Inselberg's home page
http://www.math.tau.ac.il/~aiisreal/

Robert Kosara's blog: EagerEyes (May 13, 2010)
https://eagereyes.org/techniques/parallel-coordinates

Robert Laramee's video: Introduction to Parallel Coordinates (January 5, 2016)
https://www.youtube.com/watch?v=jhhIapWYznI

1987, only two contenders were left, Hughes and IBM. For the elimination round, the FAA required Collision Detection and Automatic Conflict Resolution algorithms. Together with two coworkers (Bernard Dimsdale and Mike Boz), Inselberg applied parallel coordinates, helping IBM win the contract. That work led to at least three U.S. patents for Inselberg: 4823272 (*N*-Dimensional information display method for air traffic control—applied 1987, granted 1989), 5173861, and 5058024. After retiring from IBM, he moved to Israel and beginning in 1995 he was a visiting professor at Tel Aviv University, giving a course on parallel coordinates for many years and working with students on their research projects.

I remember Inselberg with a tear and a smile. His home page (http://www.math.tau.ac.il/~aiisreal/) tells his stories, provides a tutorial, and has amusing features like "Al's TRUISMS" that include:

THE GOLDEN RULE

He who has the gold makes the rules.

GLYME'S FORMULA FOR SUCCESS

The secret of success is sincerity. Once you learn to fake that you've got it made.

His humor is also apparent in his cynical view of administrative hindrances:

> *The heaviest element known to science was recently discovered by University physicists. The element, tentatively named Administratium (AD), has no protons or electrons, which means that its atomic number is 0. However, it does have 1 neutron, 125 assistants to the neutron, 75 vice-neutrons, and 111 assistants to the vice-neutrons. This gives it an atomic mass number of 312. The 312 particles are held together in the nucleus by a force that involves the continuous exchange of meson-like particles called memos.*

Inselberg's smiling enthusiasm, incisive humor, and creative insights will be missed, but they live on as continuing inspirations for me, as well as for many multidimensional mathematicians, visualization researchers, and system developers.

Alfred Inselberg at the Weizmann Institute February 5, 2013. (Photo by Ben Shneiderman; used with permission.)

ACKNOWLEDGMENTS

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