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Parallel Coordinates ... are better than they look!

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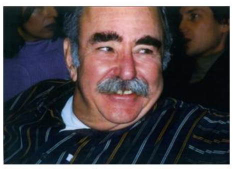
Abstract

With parallel coordinates the perceptual barrier imposed by our 3-dimensional habitation is breached enabling the visualization of multidimensional problems. The highlights, from the foundations to the most recent results and promising applications to Big Data*, are developed.*
By learning to untangle patterns *from the displays, a powerful knowledge discovery process has evolved. It is illustrated on real datasets together with guidelines for exploration and good query design. Realizing that this approach is intrinsically limited leads to a deeper geometrical insight, the recognition of M-dimensional objects recursively from their* $(M-1)$*-dimensional subsets. It emerges that any linear N-dimensionsal relation is represented by* $(N-1)$ *indexed points. The indexing in ||-coords is not well understood and will be demystified. Indexing enables the concentration of relational information into patterns and paves the way for coping with* large datasets.
For example in 3-D, two points with two indices represent a line and two points with three indices represent a plane. There result powerful geometrical algorithms (intersections, containment, proximities) and applications including classification.
A smooth surface is the envelope of its tangent planes. This is equivalent to representing the surface by its normal vectors, rather than projections as in standard surface descriptions. Developable surfaces are represented by curves revealing the surfaces' characteristics. Convex surfaces in any dimension are recognized by the hyperbola-like (i.e. having two asymptotes) regions from just one orientation. Non-orientable surfaces (i.e. like the Möbius strip) yield stunning patterns unlocking new geometrical insights. Non-convexities like folds, bumps, concavities and more are no longer hidden and are detected from just one orientation. Evidently this representation is preferable for some applications even in 3-D. The patterns persist in the presence of errors deforming in ways revealing the type and magnitude of the errors and that's good news for the applications. We stand on the threshold of cracking the gridlock of multidimensional visualization.
The parallel coordinates methodology is used in collision avoidance and conflict resolution algorithms for air traffic control (3 USA patents), computer vision (USA patent), data mining (USA patent) for data exploration and classification, multiobjective optimization, decision support, and process control.



Biography: Alfred Inselberg (AI) received a Ph.D. in Applied Mathematics and Physics from the University of Illinois (Champaign-Urbana) remaining there as Research Professor until 1966. He then held senior research positions at IBM, where he developed a Mathematical Model of the Ear TIME Nov. 74, concurrently having joint appointments at UCLA, USC, Technion and Ben Gurion University. Since 1995, he is professor at the School of Mathematical Sciences in Tel Aviv University. AI was elected Senior Fellow at the San Diego Supercomputing Center in 1996, was Distinguished Visiting Professor at Korea University in 2008 and National University of Singapore in 2011. He invented and developed the multidimensional system of Parallel Coordinates for which he received numerous awards and patents (on Air Traffic Control, Collision-Avoidance, Computer Vision, Data Mining). The textbook on Parallel Coordinates: VISUAL Multidimensional Geometry and its Applications, published by Springer, was praised by Stephen Hawking among others.