

Some Reflections on Dynamic Graphics for Data Exploration

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Introduction

- Thanks for the opportunity to help congratulate Bill on this well-deserved award.
- Outline of this talk:
 - background on early interactive graphics for data analysis
 - contributions of Bill Cleveland and others at Bell Labs
 - some of the work this influenced and motivated
 - influence and impact of this work on my efforts
 - some thoughts on current state and directions
- Slides will be posted on <http://www.stat.uiowa.edu/~luke>



Early Work on Interactive Graphics

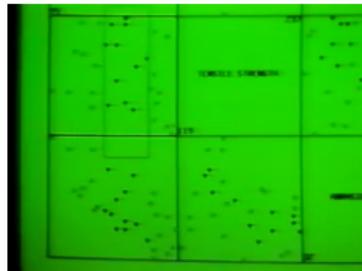
- Many early contributions, and more recent ones, are illustrated in the [video library](#) of the Statistical Computing and Statistical Graphics sections.
- Much early work focused on use of rotation to take visualization beyond two dimensions:
 - A very early contribution from Bell Labs is [Chang, \(1970\)](#)
 - An important milestone is [PRIM-9](#) for projecting, rotating, isolating, masking (FisherKeller, Friedman, and Tukey, 1975)
- Another early development is interactive probability plots (Fowlkes 1971)
 - used knobs to control parameters of distributions and transformations
- These techniques and more are shown in the Bell Labs video [Dynamic Displays of Data](#) from 1985.



A Simulation of Interactive Rotation

Brushing Scatterplots

- A new idea from Bell Labs was **brushing linked scatterplots**.
- The initial implementation used a scatterplot matrix.
- The hardware used was the ATT Teletype Model 5620 (**BLIT**)



- The ideas were described in “Brushing scatterplots” (Becker and Cleveland, 1987, *Technometrics*)
- Brushing could be used in two modes:
 - persistent
 - transient
- Persistent brushing allowed creating selections for subsetting or deletion.
- Transient highlighting aided in exploring conditional relationships.
- Interactive identification/labeling of points was also supported.
- Later versions on more advanced hardware supported color brushing.

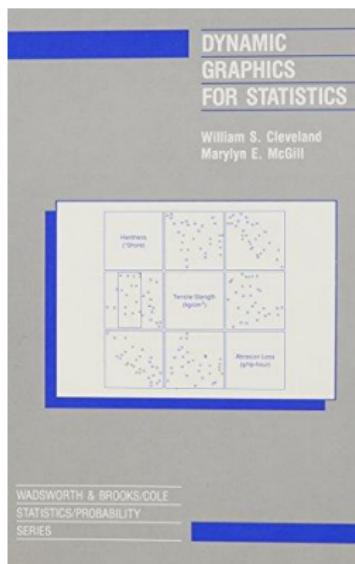


A Simulation of Scatterplot Brushing



Further Developments

- Availability of more powerful workstations lead to increased development of interactive systems
 - SGI Iris (Becker, Cleveland and Weil)
 - Apollo (Huber)
 - Lisp machines (Buja, McDonald, Oldford, Stuetzle, etc.)
- Personal computers also entered the picture:
 - MacSpin (Donoho, Donoho, and Gasco)
- Becker, Cleveland, and Wilks (1987, Statistical Science) provided an overview.
- State of the art in late 1980s presented by Cleveland and McGill's book.





Further Developments

- Some theoretical work on linking, brushing, selection
 - Furnas and Buja (1984)
 - Wills (1996)
- Extending rotation: the Grand Tour
 - Early work of Asimov, Buja, Hurley, McDonald
 - Xgobi, [ggobi](#) software
 - Cook and Swayne (2007)



A Personal Perspective

- Rick Becker demonstrated brushing on a BLIT at a JSM in the mid 1980s.
- The Macintosh was fairly new at the time.
- I was intrigued and wrote simple stand-alone programs for rotation and scatterplot matrix brushing
- Early development for the Mac was an adventure, involving
 - using the SUMMACC cross compiler on a VAX
 - downloading over phone line on a 300-baud modem
 - crash, start over
- A clear need: framework for preparing, cleaning, transforming data for visualization.
- Embedding a language, like S, seemed natural.
- Xlisp source was available, which lead to XLISP-STAT.
- Another advantage of language integration: customizable interactions
 - Example: adding a smooth to highlighted points in a linked plot



Current Directions

- Many commercial systems provide some interactive graphics support.
- Support within R includes
 - `iPlots`,
 - `rggobi`, RGL
- Original thinking was
 - interaction for exploration
 - static views for presentation, reporting
- Electronic publishing allows interaction in presentation, reporting.
- Interactive presentations are very popular in journalism
- Most common forms are
 - animation over a variable, often time (e.g. `Rosling`, `hottest year`)
 - labeling and drill down.
- Animation for presentation: shows what you want to show.
- Rotation, brushing not very common at the moment.
- Customized interaction is currently not well supported.
- Some promising efforts include `ggvis`, `animint`

Congratulations
and
Thank You