

# Some Reflections on Dynamic Graphics for Data Exploration

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- 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>



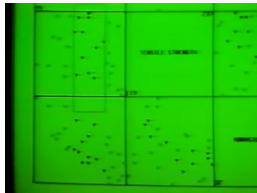
- Many early contributions, and more recent ones, are illustrated in the [video library](#) of the Statistical Computing and Statistical Graphics sections.
- Much early work focused on use of rotation to take visualization beyond two dimensions:
  - A very early contribution from Bell Labs is [Chang, \(1970\)](#)
  - An important milestone is [PRIM-9](#) for projecting, rotating, isolating, masking (Fisher, 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**)



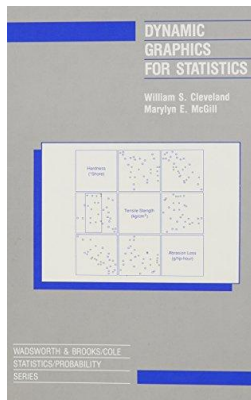
- The ideas were described in “Brushing scatterplots” (Becker and Cleveland, 1987, Technometrics)
- Brushing could be used in two modes:
  - persistent
  - transient
- Persistent brushing allowed creating selections for subsetting or deletion.
- Transient highlighting aided in exploring conditional relationships.
- 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.





- 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