filters, projections
naive approaches fall into cycles
coordinated queries
change in response to user action
animation vs. idle states
governor controls frame rate
split work into small chunks
components with many external control capabilities
continue serving queue when control is returned
tighter confederation: return control to master regularly (TJ,H3)
divide work into pieces, enqueue
continue serving queue when control is returned
guaranteed frame rate avoids slowdown with large
toolglass: semi-transparent click-through tool
magic lens: see-through tool
[Toolglass and magic lenses: the see-through interface. Eric A. Bier, Maureen C. Stone, Ken Pier, William Buxton, and Tony D. DeRose. Proc. SIGGRAPH'93, pp. 73-76.]
low-level control loops, data manipulation
choice reaction time
depends on number of choices
selection time: Fitts' Law
depends on distance, target size
path tracing
depends on width
learning: power law of practice
also subtask chunking
low-level control loops
coarse vs. fine control e.g. paper vs. pen positioning
overview+detail
depends on number of choices
different resolutions of same encoding
multiform: different visual encodings of same data
[Edward Tufte. The Visual Display of Quantitative Information, p 172]
**Coordinating Axes**
- scatterplot from components

**Coordinating Multiple Scatterplots**
- sync horizontal but not vertical scrolling

**Example: Complex Application**

**Selection**
- selection decoupled from data
- selection-dependent loading, filtering, projection
- highlighting: user-customizable differentiation of selected vs. unselected items
- video

**Critique**
- sophisticated and powerful approach to coordination
- but very large learning curve to build new apps

**Multiform Matrices and Small Multiples**
- matrices for bivariate exploration (SPLOM and other)
  - vs. small multiples for univariate
  - uniform vs. multiform multiples
  - techniques
    - juxtaposition
    - sorting/ordering
    - manipulation
  - linking multiple bivariate views

**Multiform Bivariate Small Multiple**
- common variable: per capita income
- per-column variables: type of cancer mortality
- per-row forms: scatterplot, choropleth/thematic map
- left bright green: high income, low cervical cancer
- right dark green: low income, high breast cancer
- hypoth: not screened
- hypoth: late childbearing

**Multiform Bivariate Matrix**
- scatterplots/maps, histograms along diagonal
- per-column vars: mortality, early detection, recent screening
- univariate map var: screening facility availability

**Spacefill Form**
- linked highlight of low doctor ratio counties from scatterplot
- spacefill shows it's roughly half the items

**Sorting and Linking**
- sorting
  - manual: direct manipulation from user
  - automatic: conditional entropy metric
  - automatic: hierarchical clustering to find interesting

**Excentric Labels**
- show labels around mouseover region
- demo

**Critique**
- great previous work taxonomy
- great explanation of how vis techniques used with specific data can lead to hypothesis generation
- careful use of color