Graph visualization. Animation

Lecture 6

732A98

Graph visualization

- Visualizes relational information
  - Weighted/unweighted, directional/bidirectional
- Applications
  - Social networks
  - Biological networks (genetic)
  - Computer networks
  - Railway/bus networks
  - …

Tree visualization

- Space-filling methods (sunburst chart, treemaps, circle packing)
- Non-space filling methods (trees)
- Aesthetics: node color/ size, link color/size

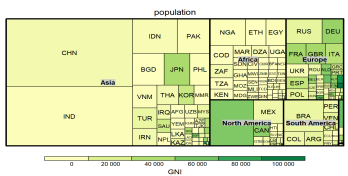
Treemaps, **Circle packing** and **Sunburst diagrams**

- Recursively divides the space into areas according to the hierarchy (e.g. catalogue structure)
- Aesthetics: size and color
- Assuming: $size(parent) = \sum size(kids)$

Treemaps

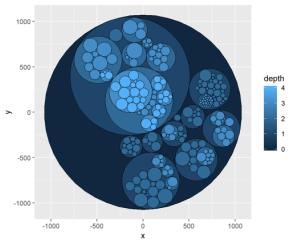
- Analysis: Comparing size/color of hierarchies between/within different levels

Example: World population



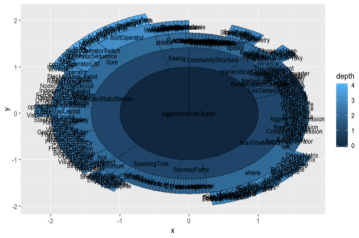
Circle packing

Example: Hierarchy for Flare ActionScript Library



Sunburst

Example: Hierarchy for Flare ActionScript Library



Tree

- Aesthetics: Node/link size, node/link color
- Can be used for classification result analysis
- Analysis
  - Analyse each branch and terminal nodes
  - Compare information between nodes
  - Compare information between branches

Tree

Picture here

Graph Visualization

- Layout has great impact (influences understanding a lot)
- Different layouts proposed
  - Force-directed layout
    - Repulsive and Spring forces
    - Optimization used to find equilibrium
  - Fixed layouts: circular, line,…
  - Minimizing other objectives (e.g. symmetry, edge crossing)

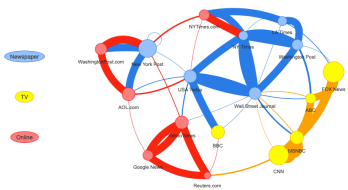
Graph visualization

Example: Network of hyperlinks and mentions among news sources

See Network example 1

- Now adding node_size="audience size", link_size=amount of references

See Network example 2



Graph visualization

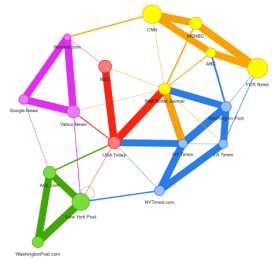
Analysis:

- Which nodes are hubs?
- Which links are strongest?
- Which nodes are n steps away from some node?
- Components with strong connections?
  - Relationships to groups?
- How are different groups connected?
- Shortest path between nodes
- Community detection (densely connected nodes)
- Other interesting substructures

Graph visualization

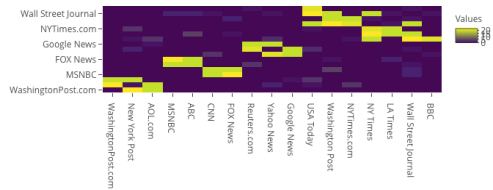
Example: Community detection based on edge betweeness

See Network example 3



Graph visualization

- Graph can be represented as adjacency matrix
- Seriation methods can be used
- Communities can be detected by heatmaps



Graph Visualization in R

- A plenty of packages available
  - `igraph`: rich functionality, poor graphics
  - `visNetwork`: interactive graph visualization, can use `igraph` objects
  - `ggraph`: static graphs, based on the grammar of graphics, can use `igraph`
  - `ggnet2` in `GGally`: static graphs
  - …
- Describing graph objects - very package dependent
  - `igraph/visNetwork/ggraph`:
    - Nodes: data frame with "id" column (and other attrs)

Animation

- Eye is drawn to similar motions and outlying motions
- Advantages
  - Effective at attracting attention
  - Time=one extra aesthetics
  - Easily perceived in peripheral vision ->many features can be captured at one time point
- Disadvantages
  - Unappropriate transformation (transition) -> false conclusions
  - Speed of the graphics may hide important details/make boring

Animation- recommendations

- Maintain valid data during transitions
  - Example: using splines
- Be careful when using interpolations: use appropriate models
- Group similar transitions
- Minimize occlusion
- Use simple transitions
- If trajectory is stable, use ease-in, ease-out
- Make transition as long as needed but no longer.

轨迹

Gapminder

See http://www.gapminder.org

- Gapminder is
  - A database that stores important world statistics (by country)
  - Each dataset can be analysed online with Motion Chart
  - Popularized by Hans Rosling
- Check "Life expectancy" (years) in Gapminder

Gapminder

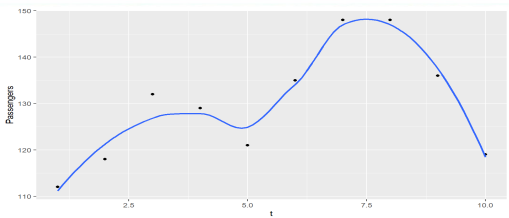
Life expectancy set

- How the minimum and maximum life expectancies changed after 200 years
- Which countries had in general the highest life expectancy? Lowest lifexpectancy? Highest income level? Lowest income level?
- What happened after 1946 and why?
- Compare development of China and USA (mark this countries and use "trace")

How to create an animation?

- Limited amount of timepoints
- Smooth transition is desired
- For each aesthetics x, consider interpolation $x'(t)$
  - How to create?
    - Linear interpolation, splines, kernel smoothers…
    - Compute path length $s(t)$
    - Insert intermediate frames $t_1, \dots, t_n$ with $x'(t_1), \dots x'(t_n)$

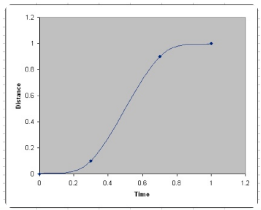
How to create an animation?



How to create an animation?

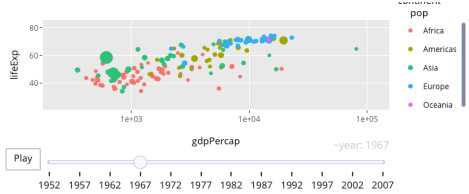
Inserting intermediate values:

- Smooth interpolation
- Ease in, ease out (focuses user on main frames)
- … (https://easings.net/)



Animation in R

- Motion charts : googleVis package
- Plotly: various animation, set time variable to `frame` aesthetics
  - Motion charts are simpler than googleVis



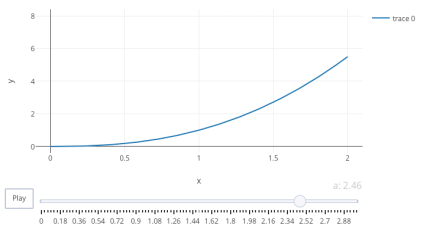
Animation in R

Example: power function

```
library(plotly)

m=matrix(nrow=0,ncol=3)
for (a in seq(0,3,by=0.03)) {
  x<-seq(0,2,0.01)
  y<-x^a
  m<-rbind(m,cbind(x,y,a))
}

df=as.data.frame(m)

plot_ly(df, x=~x, y=~y, frame =~a)%>%add_lines()%>%animation_opts(
  100, easing = "cubic", redraw = F
)
```


Animation in R

Example: power function



2D-tours

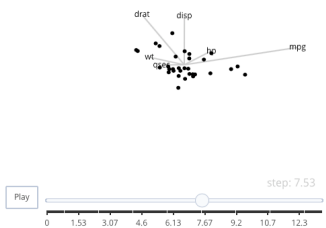
- MDS and PCA projections
  - Is one projection enough to understand data?

2D-tours

- Idea
  - Investigate various projections
  - Connect them into animation
- What to analyze?
  - Same as in scatterplots plus
  - Which variables contribute to projections
    - Patterns in lower dimensional manifold?
- Types of 2d-tours: grand tour and guided tour

2D-tours

- Grand tour for Car data



Projection math

- Data matrix $X = [n \times p]$
- Projection matrix $A = [p \times d]$, $d = 2$
  - Rows in A: contribution of ith coordinate to projection
  - Columns in A: coordinate of projecting vectors in R^p
- Projected data $Z = X \cdot A$
- Example: $X = \begin{pmatrix} 2 & 4 & 3 \\ 6 & 2 & 1 \\ 2 & 9 & 9 \end{pmatrix}, A = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{pmatrix}$

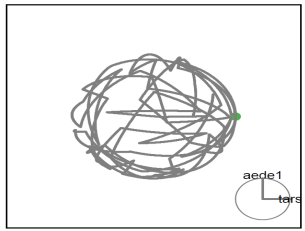
Grand tour

- Idea: explore projections randomly

1. Select some projection A_1
2. Select next projection randomly A_2
3. Create shortest path projections $A_1^1, \dots, A_1^k$ from A_1 to A_2
4. Select next projection randomly A_3
5. …

Grand tour

Source: 'Grand Tours, Projection pursuit guided tours' by Cook et al



Guided tour

- Idea: focus on "interesting" projections
  - Interest measure: projection pursuit index $I(XA)$
  - Go through local $\max I(XA)$

- Various PP indices: Holes, central mass,…

Guided tour

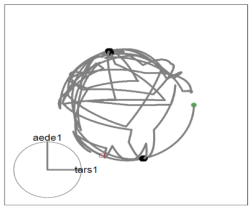
Algorithm:

- Select some projection A_a, calculate I_a
- For i=1,2,…
  - $A_i = A_a + c^i B$, B- random direction, c^i - "cooling parameter"
  - Move to A_i with probability depending on ΔI (and create shortest path intermediate projections)
  - Set $A_a = A_i$ if moved.

Guided tour

- Note: path goes often through same points…

Source: "Grand tours, Projection Pursuit Guided Tours" by Cook et al



Read Home

- Chapter 9, 12.7
- Cook, D., Buja, A., Lee, E. K., & Wickham, H. (2008). Grand tours, projection pursuit guided tours, and manual controls. In Handbook of data visualization (pp. 295-314). Springer, Berlin, Heidelberg.
- Plotly book Ch 5.1
- http://kateto.net/networks-r-igraph
- https://datastorm-open.github.io/visNetwork/
- https://www.data-imaginist.com/2017/ggraph-introduction-layouts