第四讲：交互技术与动画

信息可视化

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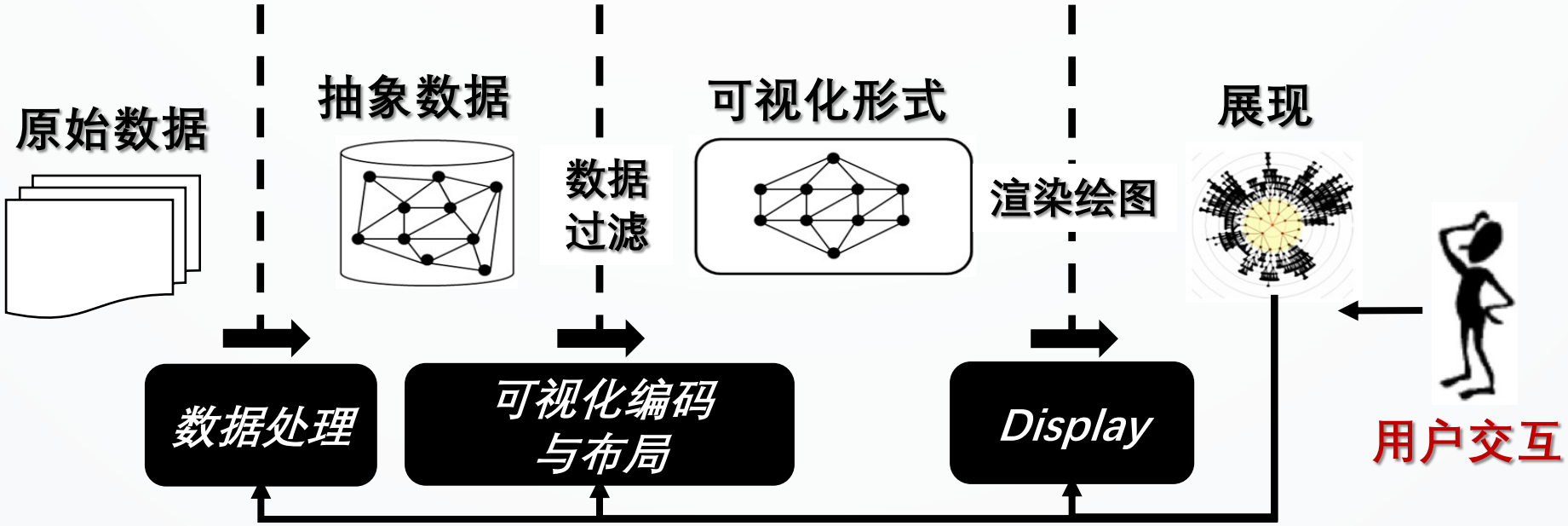
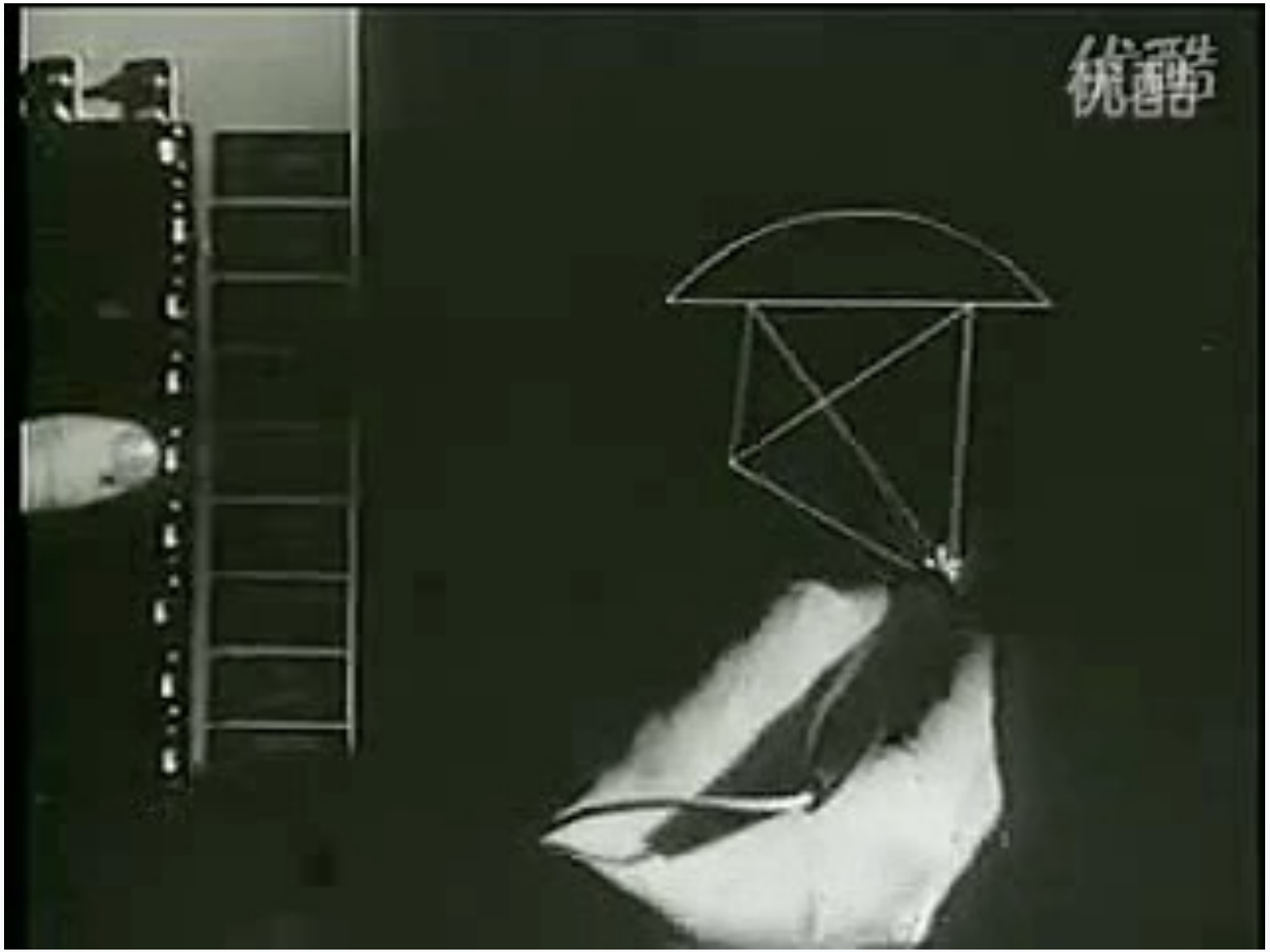
智能大数据可视化实验室

如何创建可视化



信息可视化参考模型


优酷

交互

- **常见交互类型**
- **交互范式1：概览+细节**
- **交互范式2：焦点+上下文**

常见交互类型

- Ji Soo Yi et al (TVCG 2007)
  1. 选择 (Select)
  2. 导航 (Explore)
  3. 重配 (Reconfigure)
  4. 编码 (Encode)
  5. 抽象/具象 (Abstract/Elaborate)
  6. 过滤 (Filter)
  7. 关联 (Connect)

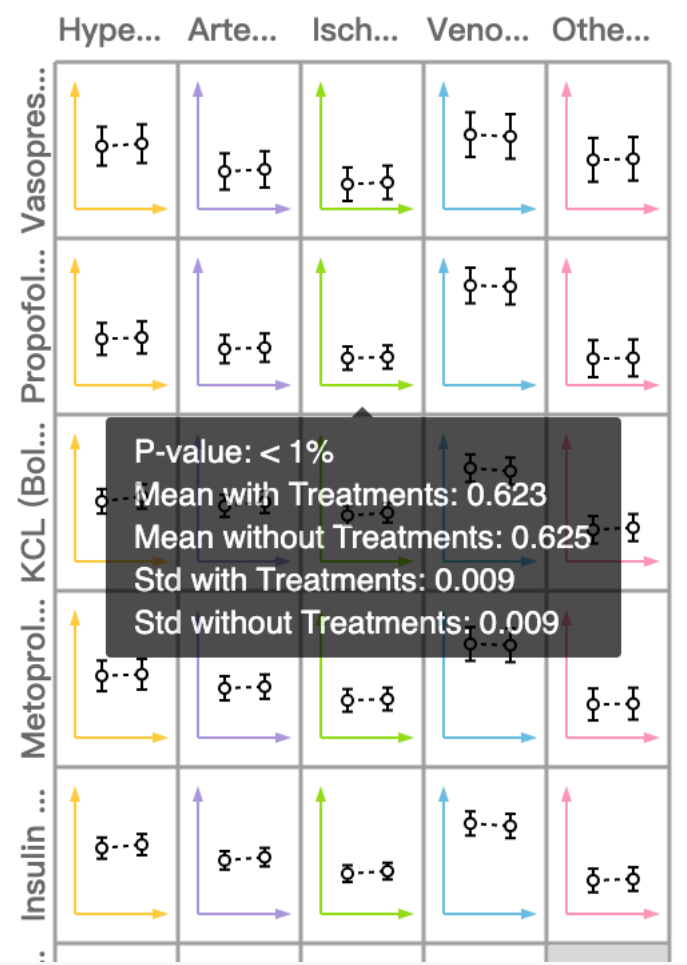
Yi, Ji Soo, Youn ah Kang, and John Stasko. "Toward a deeper understanding of the role of interaction in information visualization." *IEEE transactions on visualization and computer graphics* 13.6 (2007): 1224-1231.

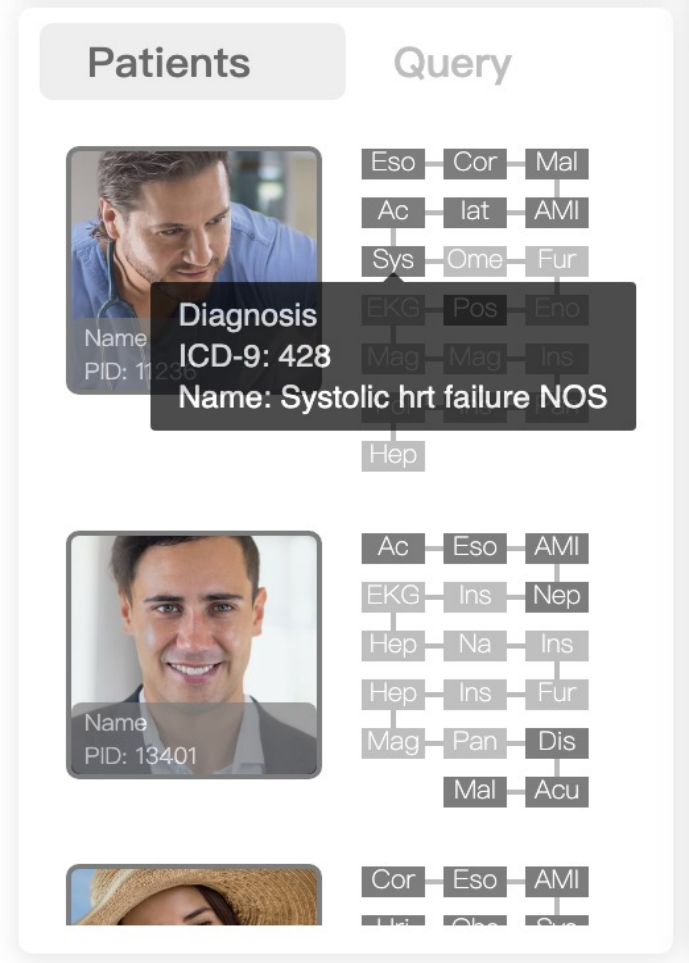
1. 选择

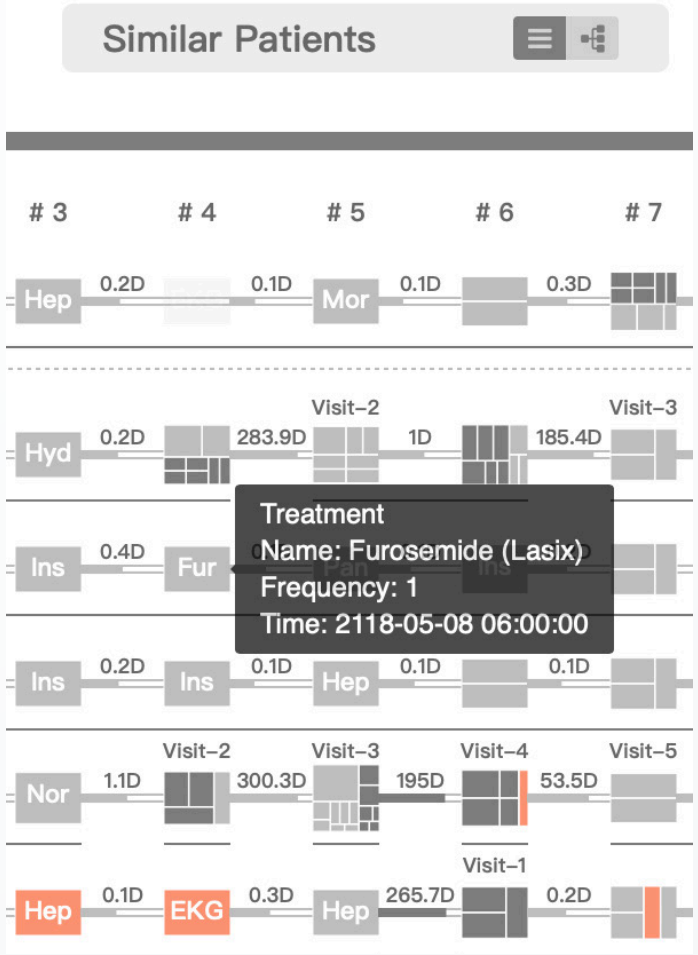
- 任务：标记感兴趣的数据点以追踪其变化

- 例如：
  - 在地图上找一个地点标记

选择的具体方式：鼠标悬停并显示提示框





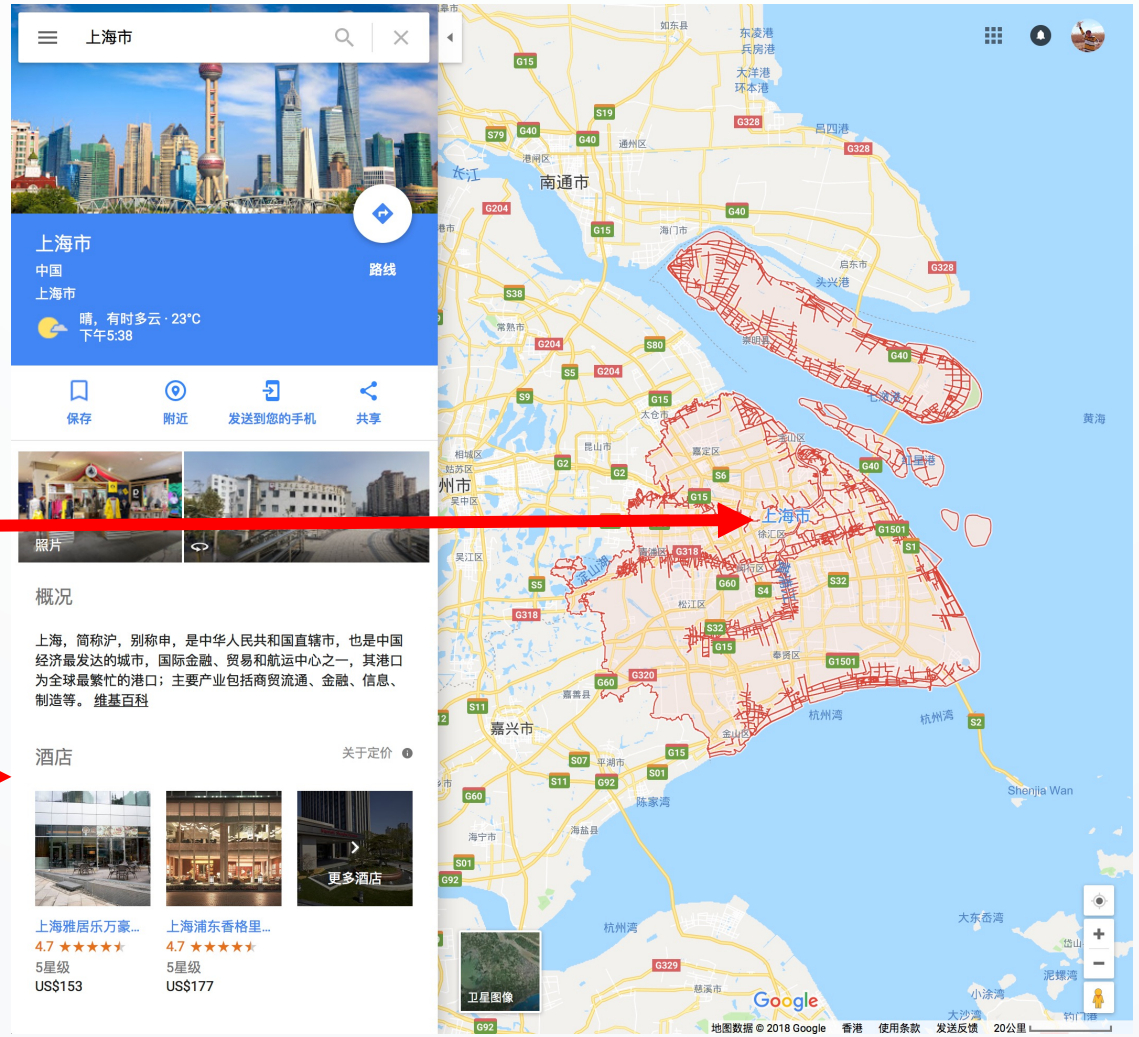


Zhuochen Jin, Shuyuan Cui, Shunan Guo, David Gotz, Jimeng Sun, and Nan Cao, "CarePre: An Intelligent Clinical Decision Assistance System",
ACM Transactions on Computing for Healthcare

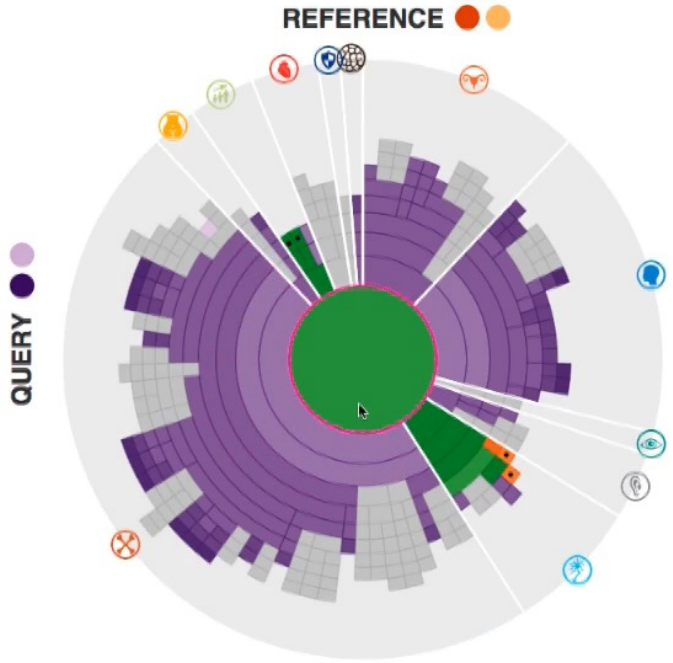
选择的具体方式：鼠标点击

选择

属性

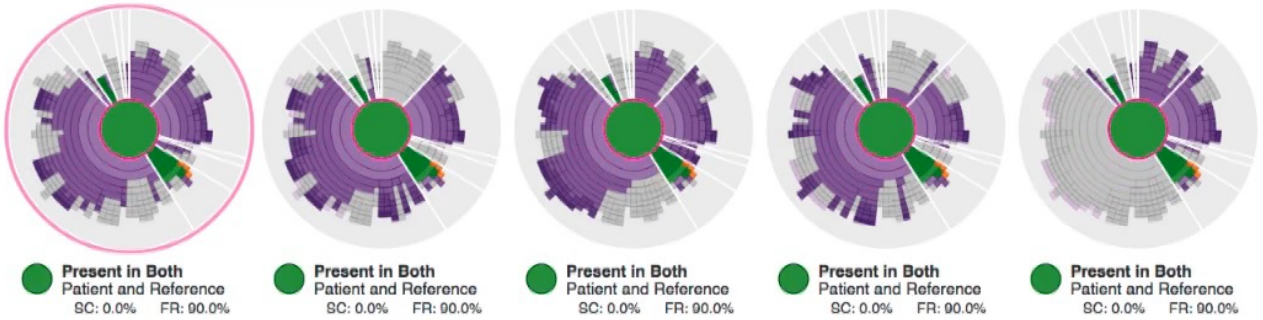


PhenoBlocks | Advanced | Edit Phenotypes | Collapse



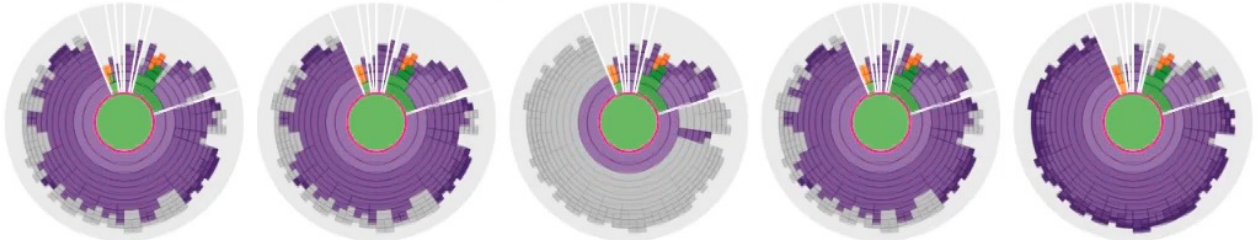
- Phenotypic abnormality
- 11 pairs of ribs
- Absent speech
- Bilateral conductive hearing impairment
- Brachydactyly syndrome
- Broad fingertip
- Broad thumb
- Carious teeth
- Celiac disease
- Coarctation of aorta
- Cryptorchidism
- Decreased body weight
- Defect in the atrial septum
- Dental malocclusion
- Dilatation of the renal pelvis
- Dislocated radial head
- Fifth finger distal phalanx clinodactyly
- Hip dysplasia
- Hypermetropia
- Hypospadias
- Inguinal hernia
- Intellectual disability, borderline
- Intellectual disability, moderate
- Long nose

#136140 FLOATING-HARBOR SYNDROME 11.5%



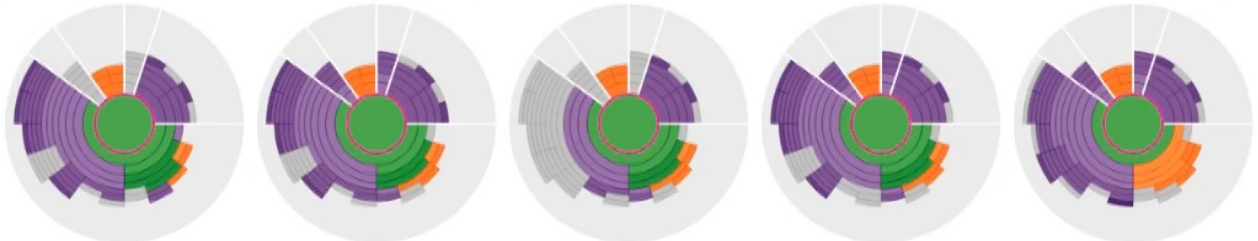
Present in Both
Patient and Reference
SC: 0.0% FR: 90.0%

#614261 MICROCEPHALY-CAPILLARY MALFORMATION SYNDROME 7.4%



Present in Both
Patient and Reference
SC: 0.0% FR: 5.0%

#604213 CHUDLEY-MCCULLOUGH SYNDROME 6.4%



Present in Both
Patient and Reference
SC: 0.0% FR: ---

- Present in Both
- Absent in Both
- Unknown in Query, Present in Reference
- Unknown in Query, Absent in Reference
- Present in Query, Unknown in Reference
- Absent in Query, Unknown in Reference
- Present in Query, Absent in Reference
- Absent in Query, Present in Reference
- Unknown in Both

2. 导航

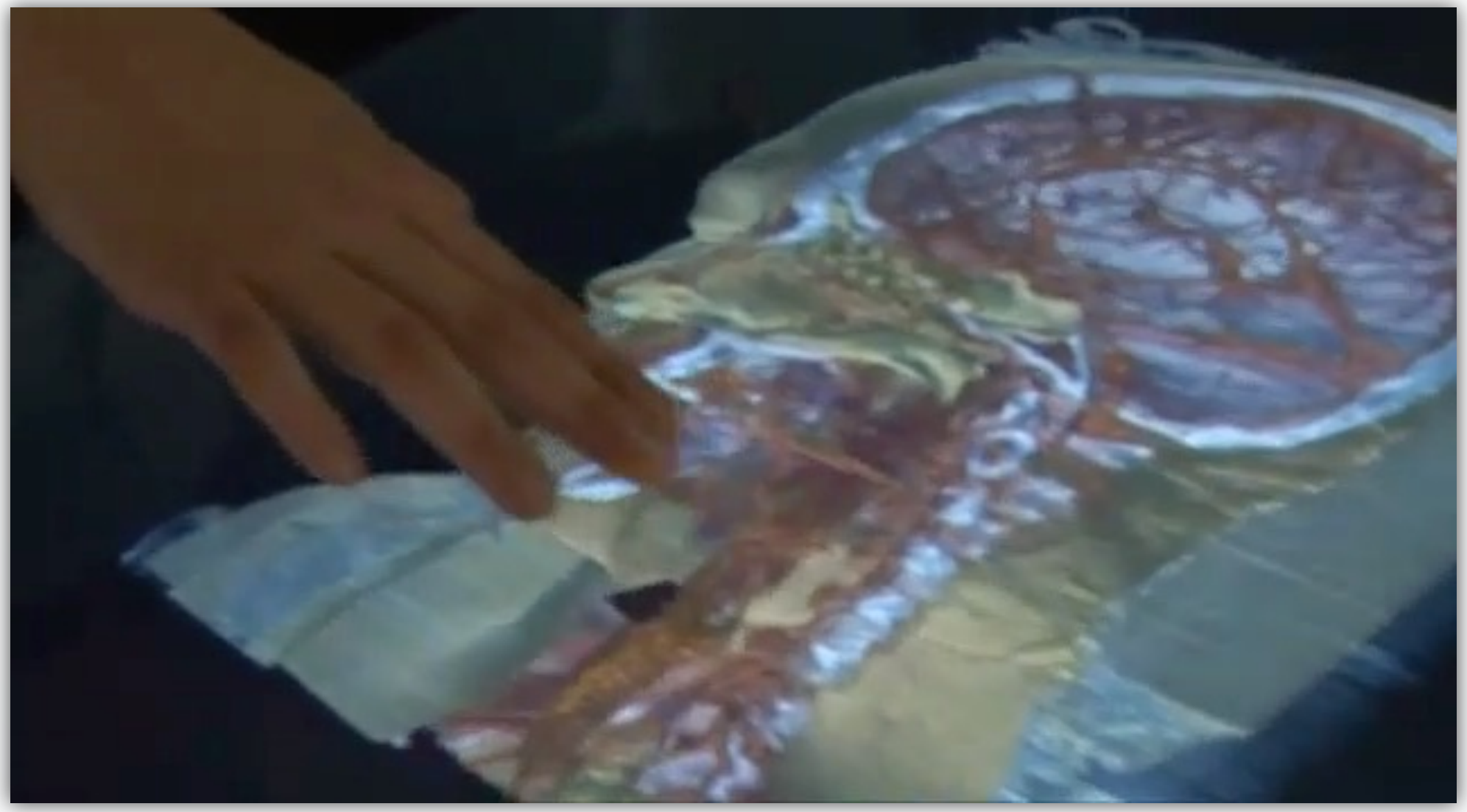
- 任务：展示数据的不同子集

- 例如：
  - 在谷歌地球中查看地理信息

导航的具体方式：直接引导（Direct Walk）

导航栏

导航的具体方式：拖拽与缩放

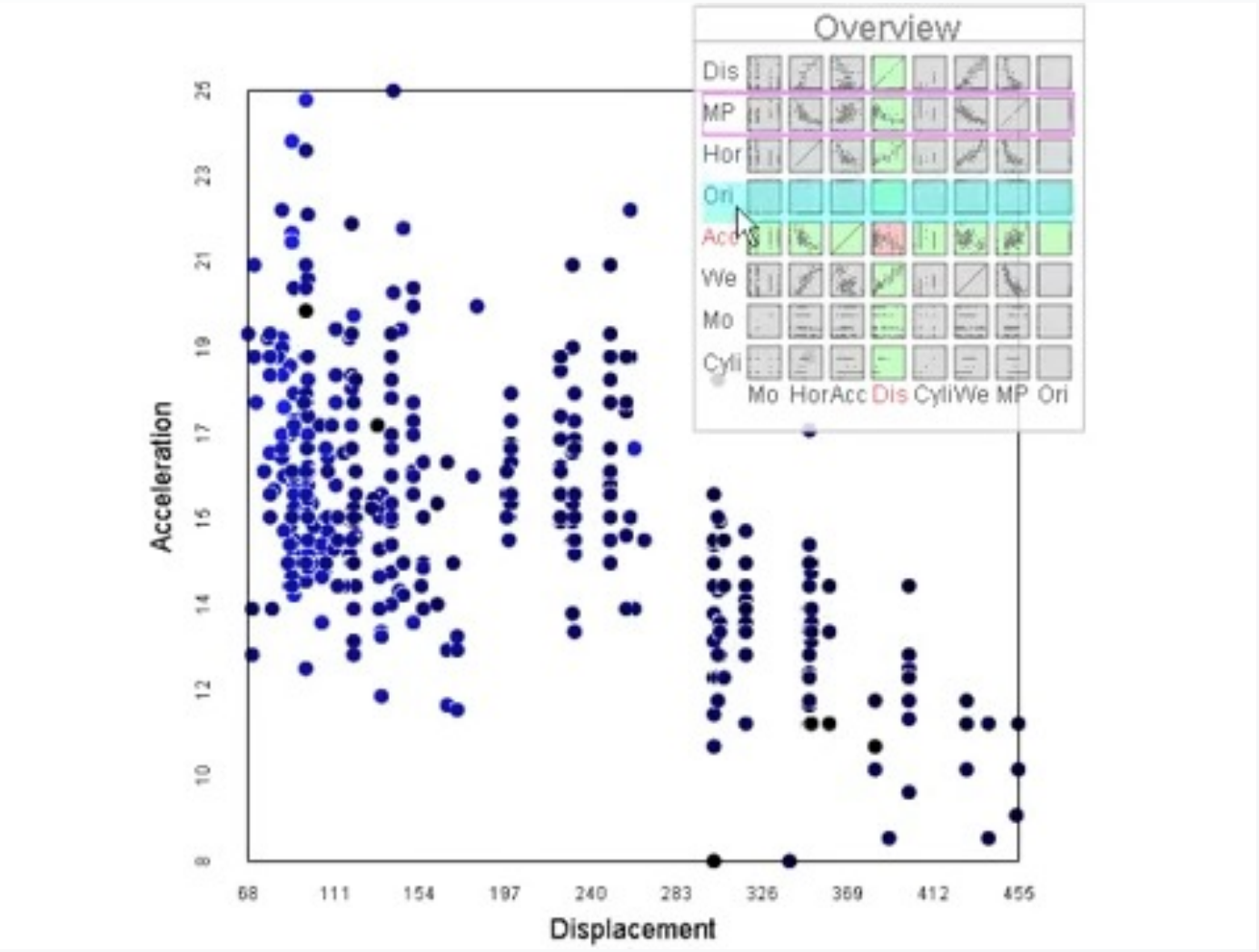


3. 重构

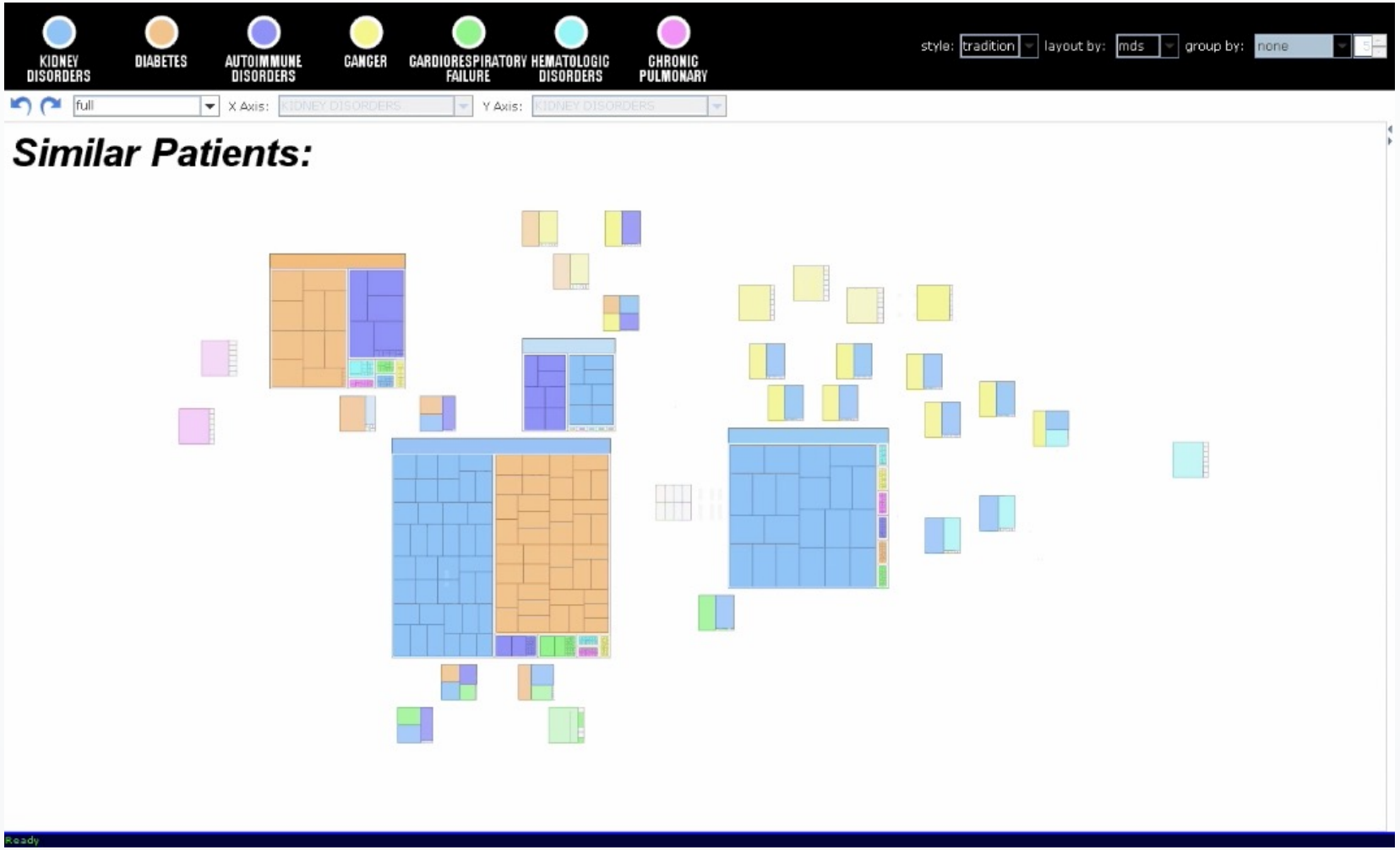
- 任务：改变可视化的空间布局以提供不同的视角

- 例如：
  - 改变散点图的数据轴映射

- 数据本身不会发生变化

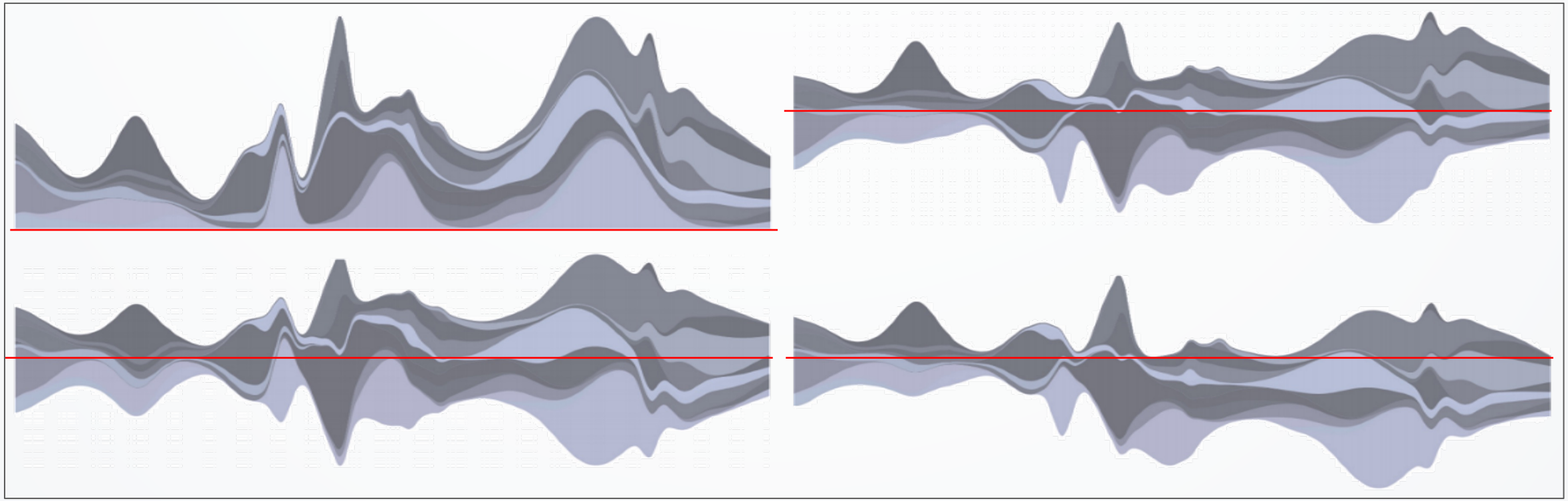


重构的具体方式：视图重组



Cao, Nan, et al. "Dicon: Interactive visual analysis of multidimensional clusters." IEEE transactions on visualization and computer graphics 17.12 (2011): 2581-2590.

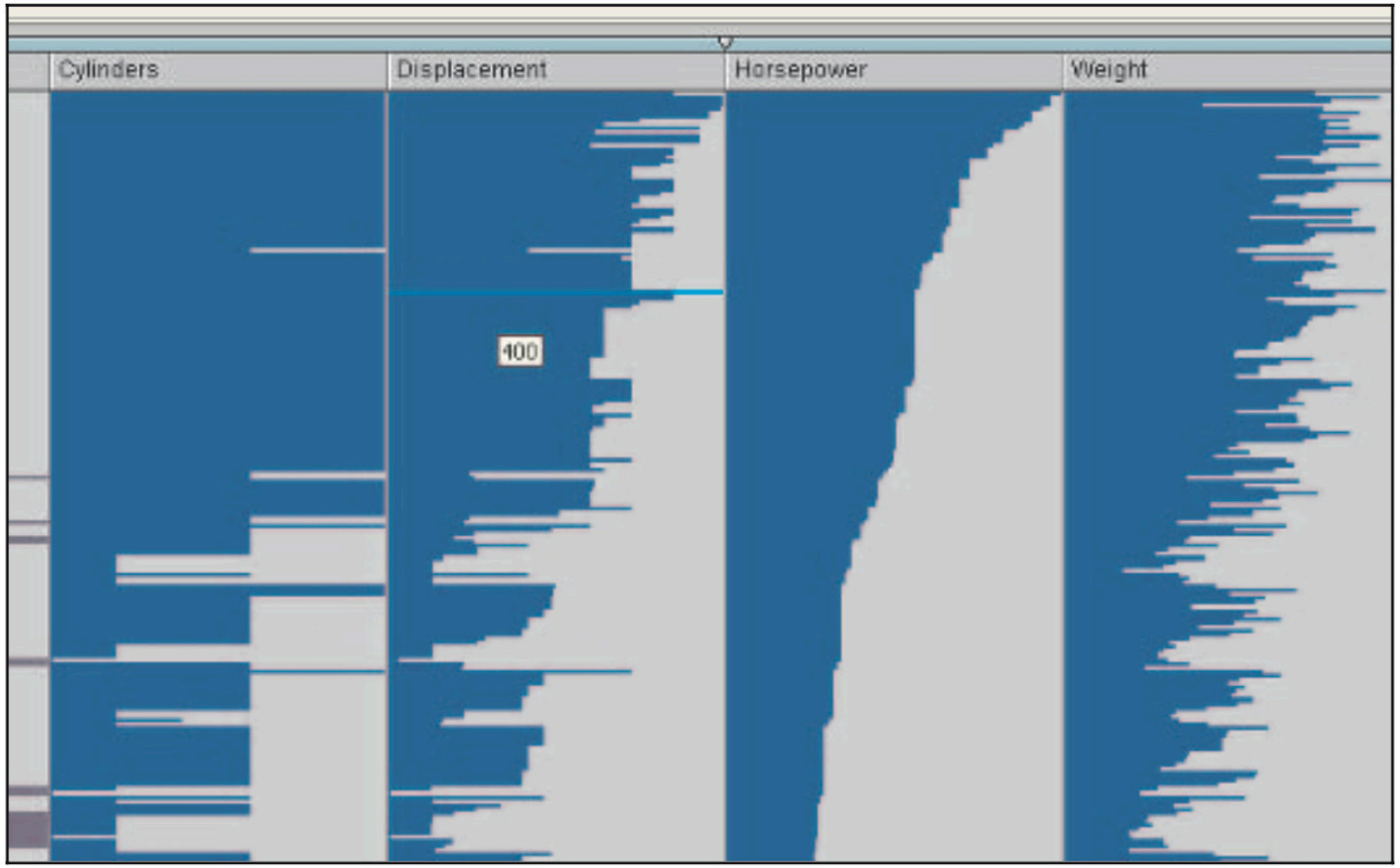
重构的具体方式：视图重构



Change of the baseline position

Cao, Nan, et al. "Dicon: Interactive visual analysis of multidimensional clusters." IEEE transactions on visualization and computer graphics 17.12 (2011): 2581-2590.

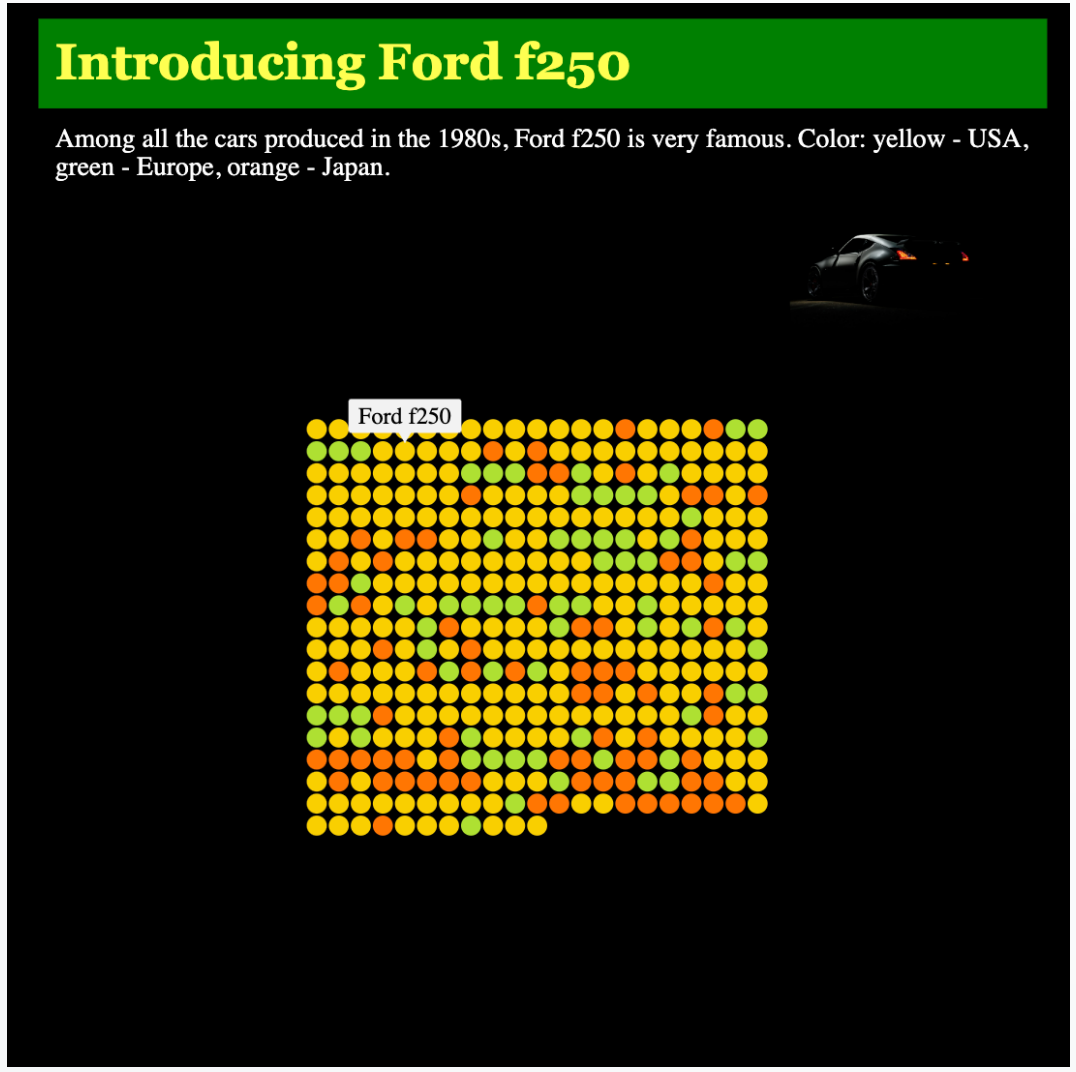
重构的具体方式：排序变换

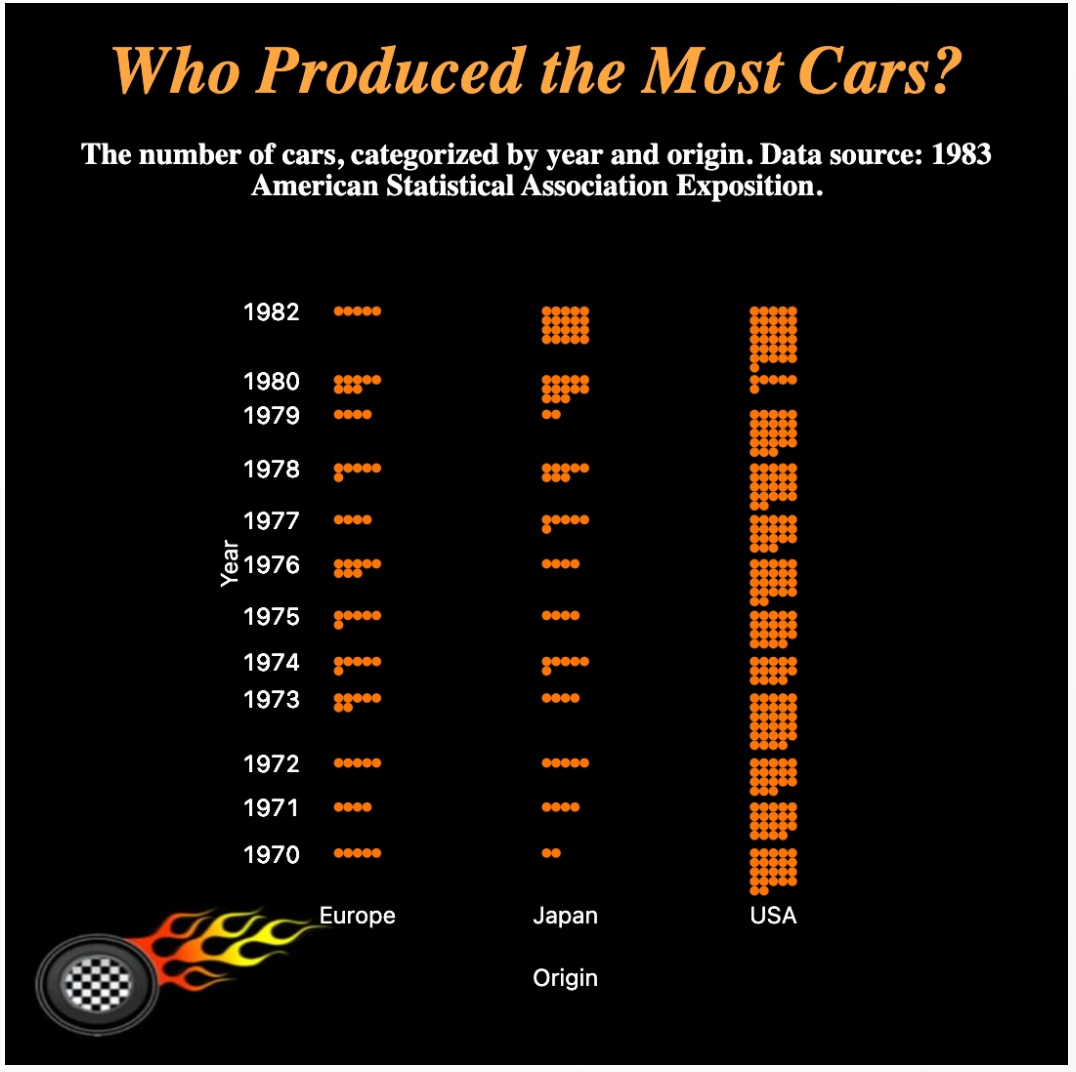


针对图表中的horsepower列进行排序

Yi, Ji Soo, Youn ah Kang, and John Stasko. "Toward a deeper understanding of the role of interaction in information visualization." *IEEE transactions on visualization and computer graphics* 13.6 (2007): 1224-1231.

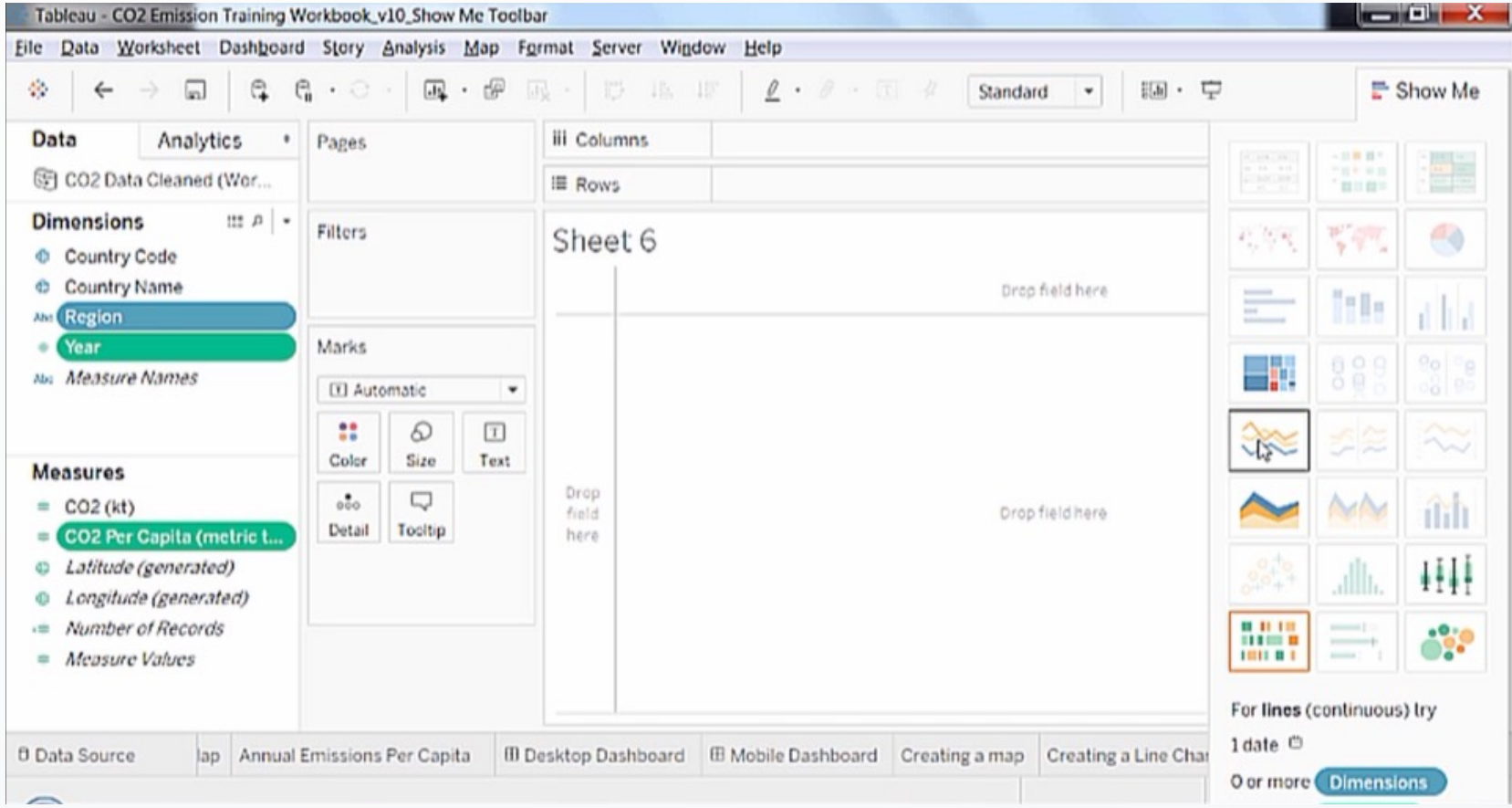
重构的具体方式：布局变换

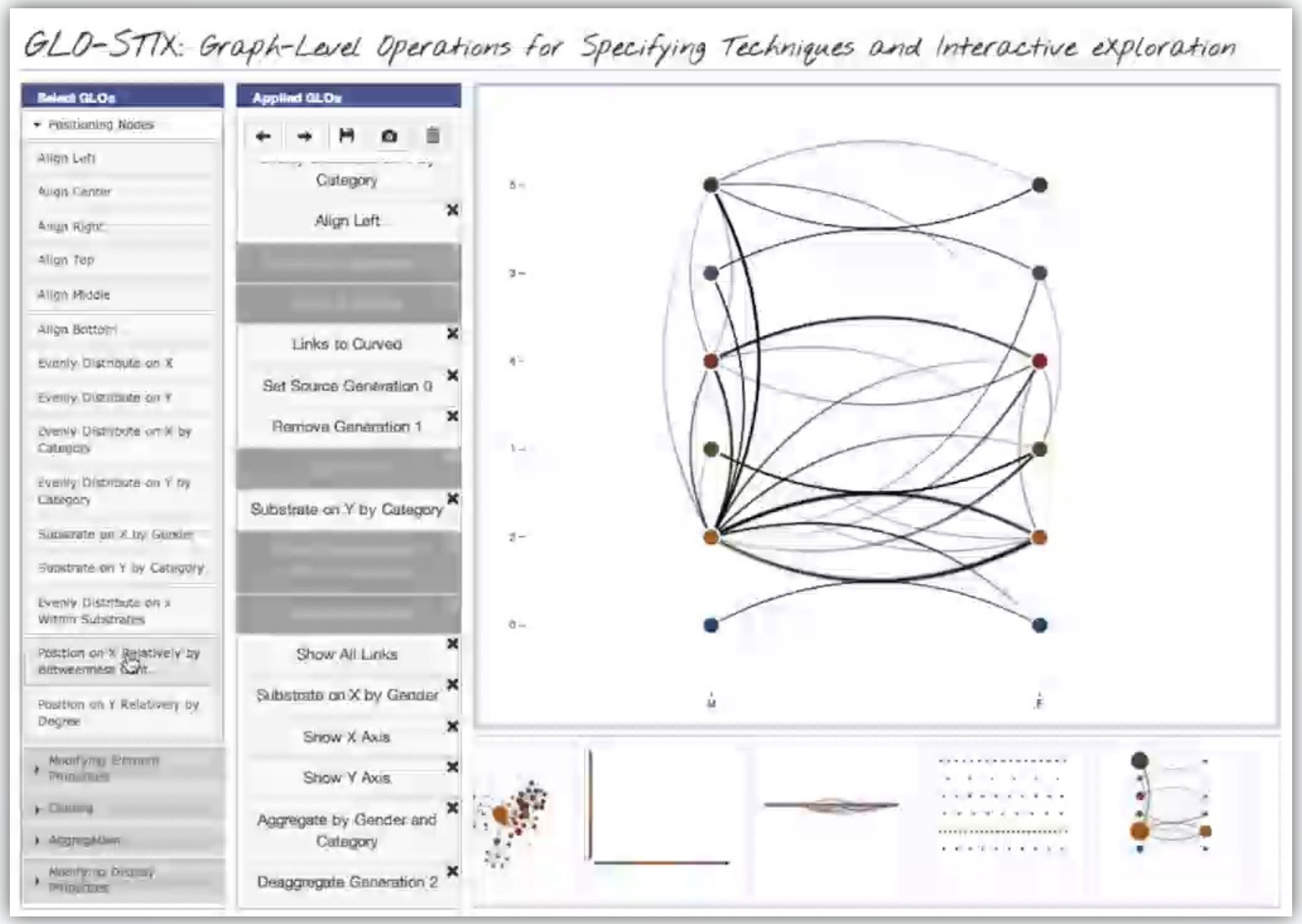




4. 编码

- 任务：改变可视化的视觉外观以展现不同的表示形式
- 例如：
  - 改变颜色、大小、方向、形状
- 数据本身不会被改变





Stolper C D, Kahng M, Lin Z, et al. Glo-stix: Graph-level operations for specifying techniques and interactive exploration[J]. IEEE transactions on visualization and computer graphics, 2014, 20(12): 2320-2328.

4. 抽象/具象

- 任务：展示更多或更少的数据细节以提供不同细节等级的信息

- 例如：
  - 课程层次结构

5. 过滤

- 任务：基于限定条件展示数据

- 例如：
  - 查询
  - 动态查询

数据库查询

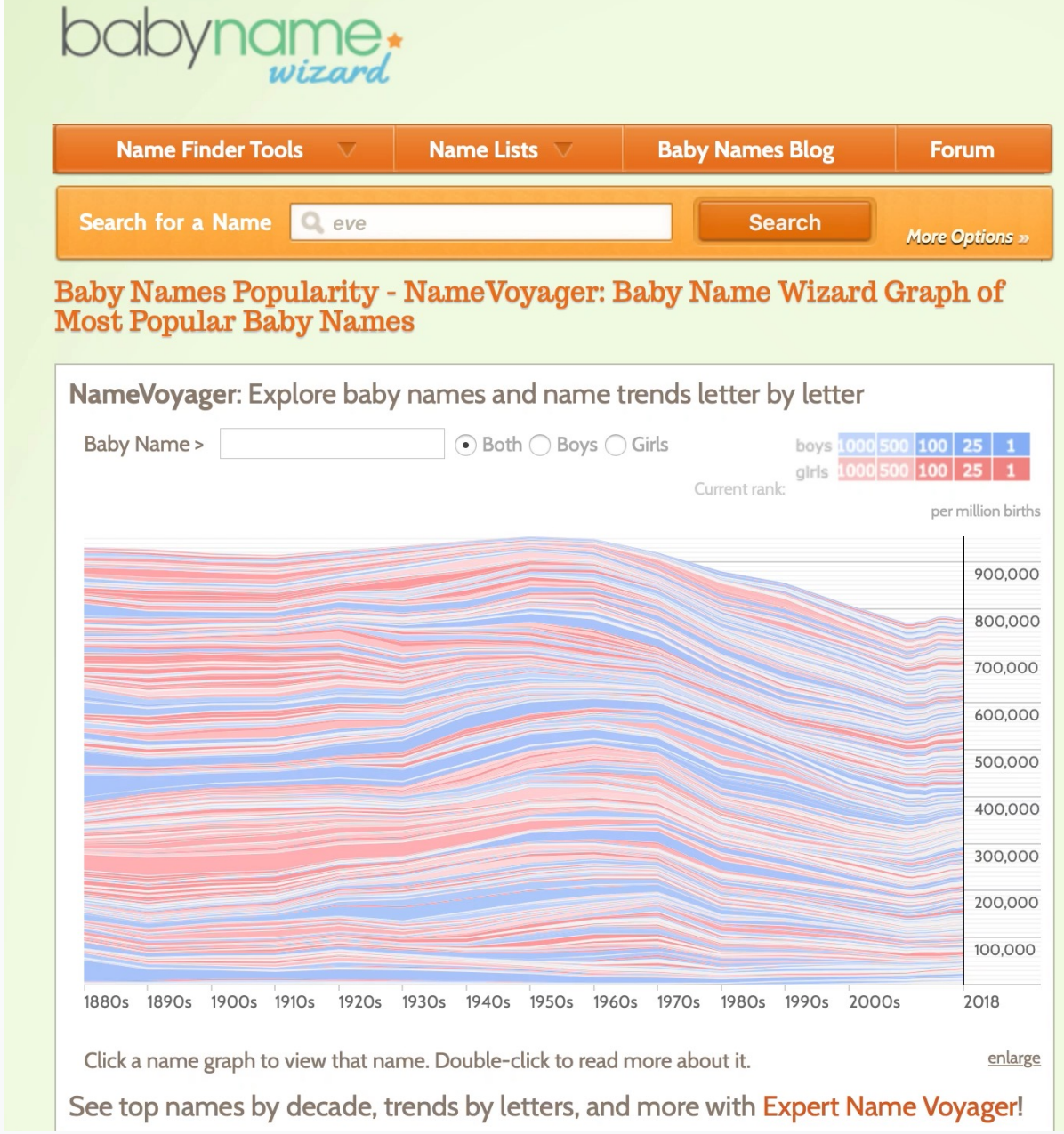
Query language

– **Select** house-address
From atl-realty-db
Where price >= 200,000 **and**
price <= 400,000 **and**
bathrooms >= 3 **and**
garage == 2 **and**
bedrooms >= 4

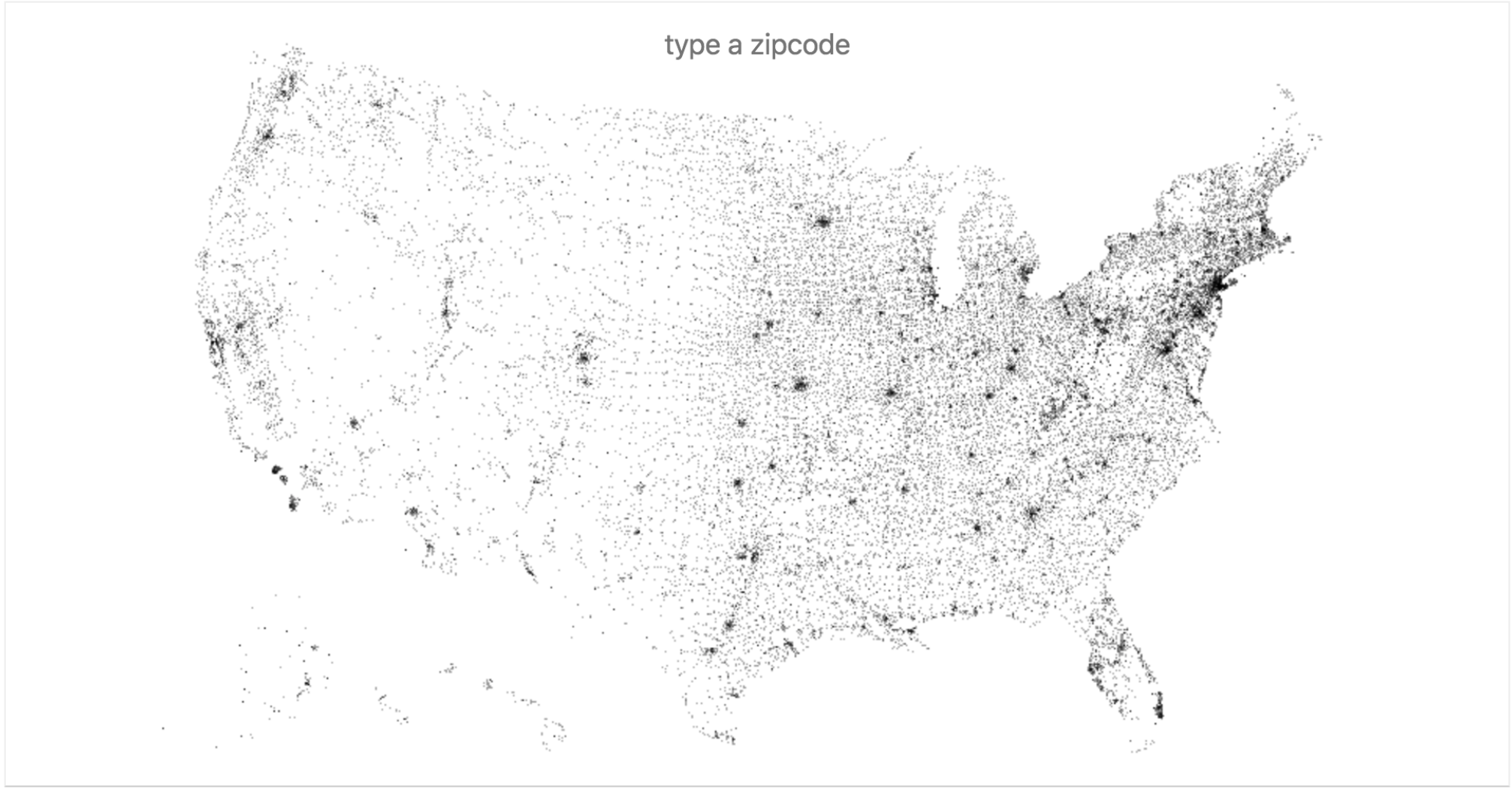
- 124 hits found
  - 1. 748 Oak St. - a beautiful …
  - 2. 623 Pine Ave. -
  - …
- 0 hits found

过滤的具体方式：动态查询

- 通过交互过滤，将结果数据高效实时地返回给用户



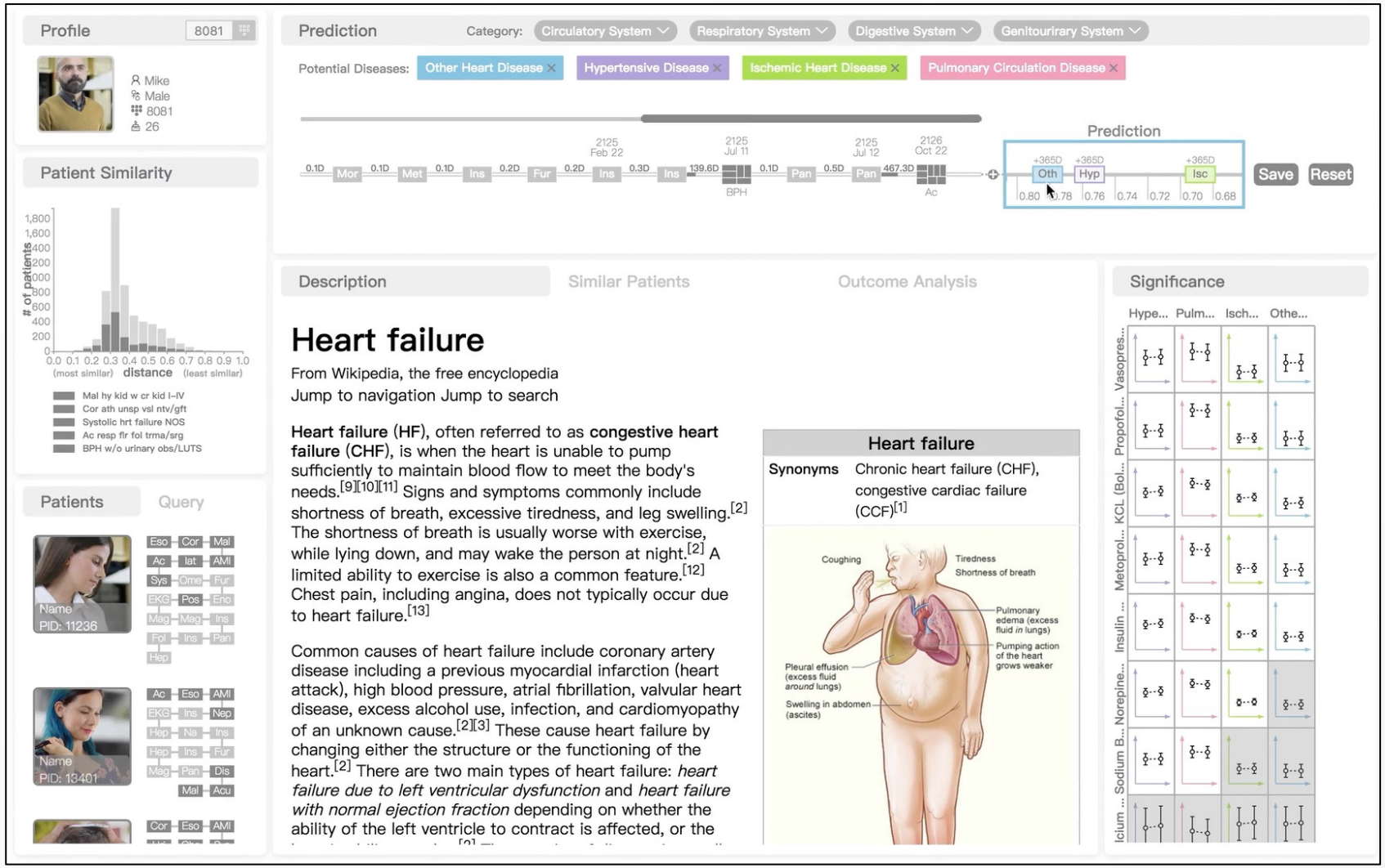
Zipdecode



https://bl.ocks.org/mbostock/5180185

过滤的具体方式：刷选直方图

- 通过直方图显示数据分布，并以此知道用户对数据进行刷选过滤

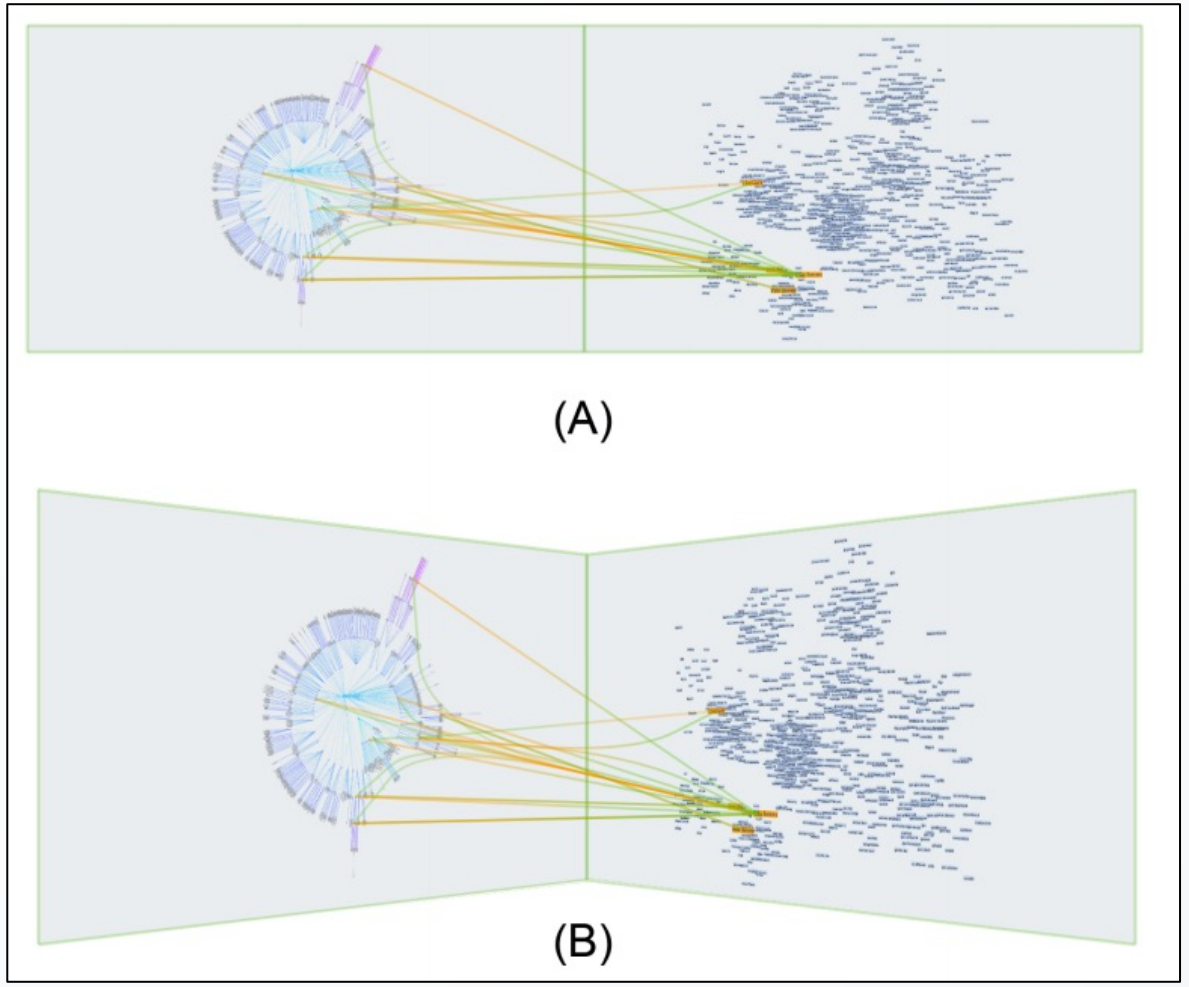


Zhuochen Jin, Shuyuan Cui, Shunan Guo, David Gotz, Jimeng Sun, and Nan Cao, CarePre: An Intelligent Clinical Decision Assistance System, ACM Transactions on Computing for Healthcare

6. 关联

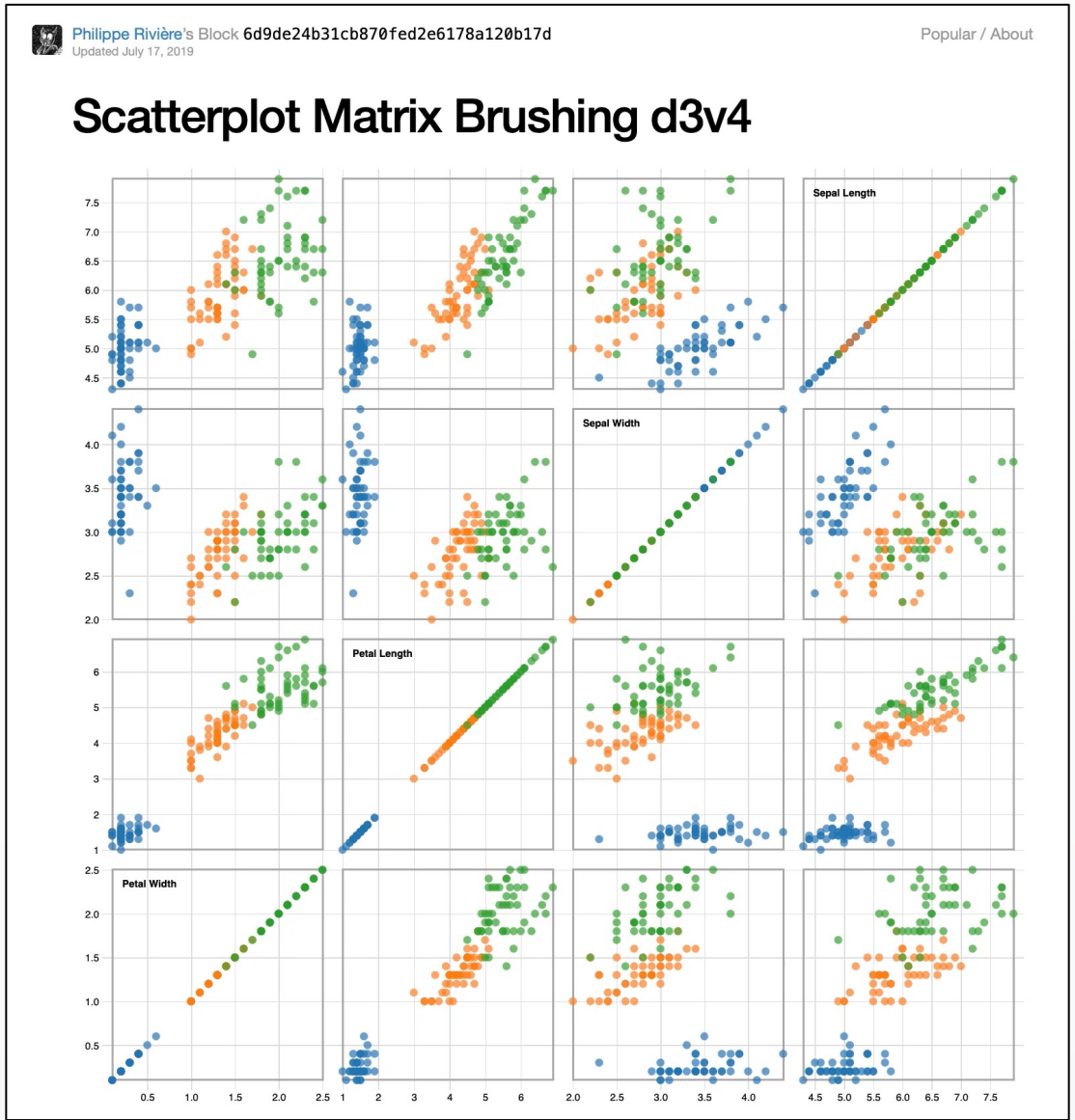
- 任务：显示数据之间的联系

- 例如：
  - 连接高亮

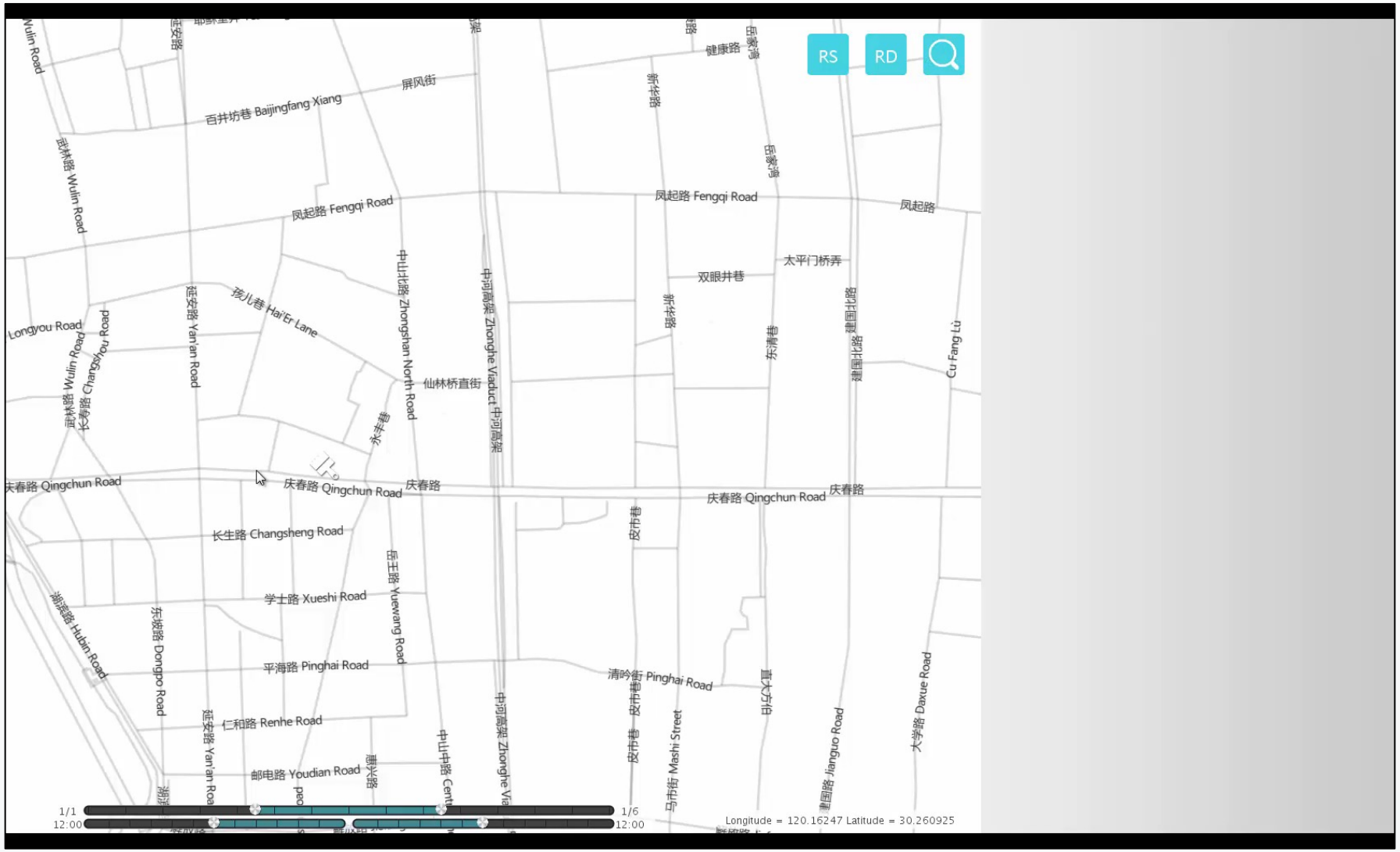


Collins, Christopher, and Sheelagh Carpendale. "VisLink: Revealing relationships amongst visualizations." *IEEE Transactions on Visualization and Computer Graphics* 13.6 (2007): 1192-1199.

关联的具体方式：刷选&连接（Brush & Link）



关联的具体方式：刷选&连接（Brush & Link)



交互

- 常见交互类型
- **交互范式1：概览+细节**
- 交互范式2：焦点+上下文

交互范式1: 概览+细节（Overview + Detail）

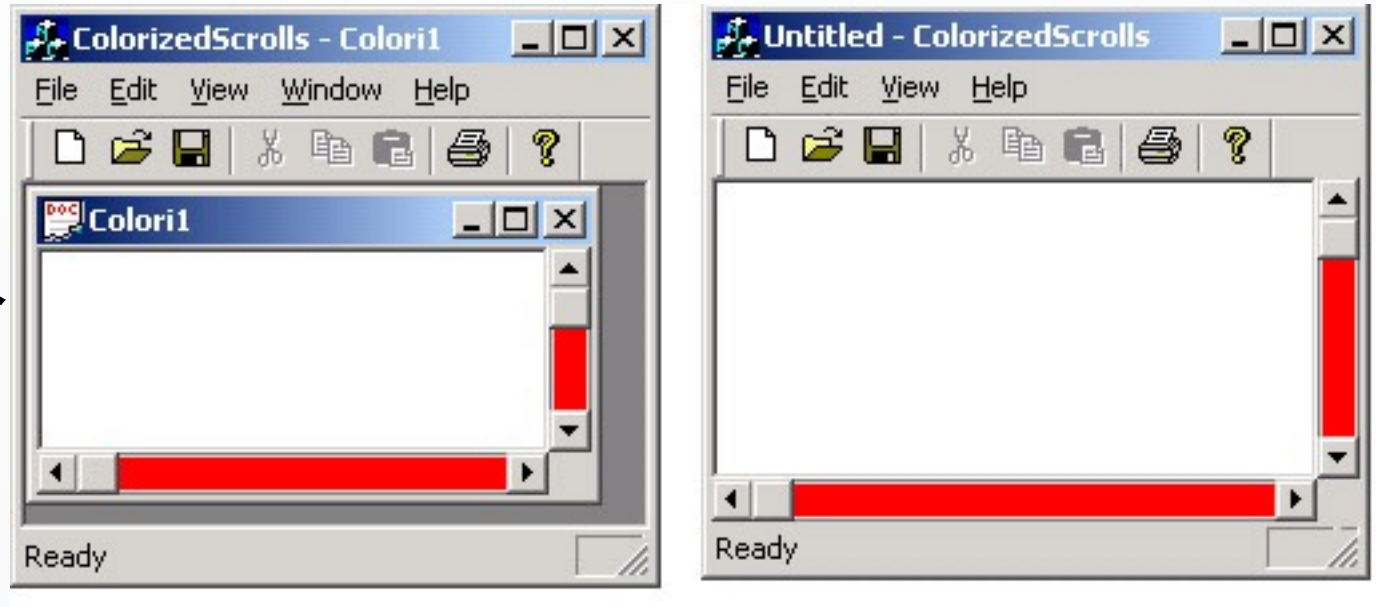
- 任务：显示全局概览的同时展示部分细节

- 实现手段：
  - 可视化
  - 交互方式
  - 两者兼用

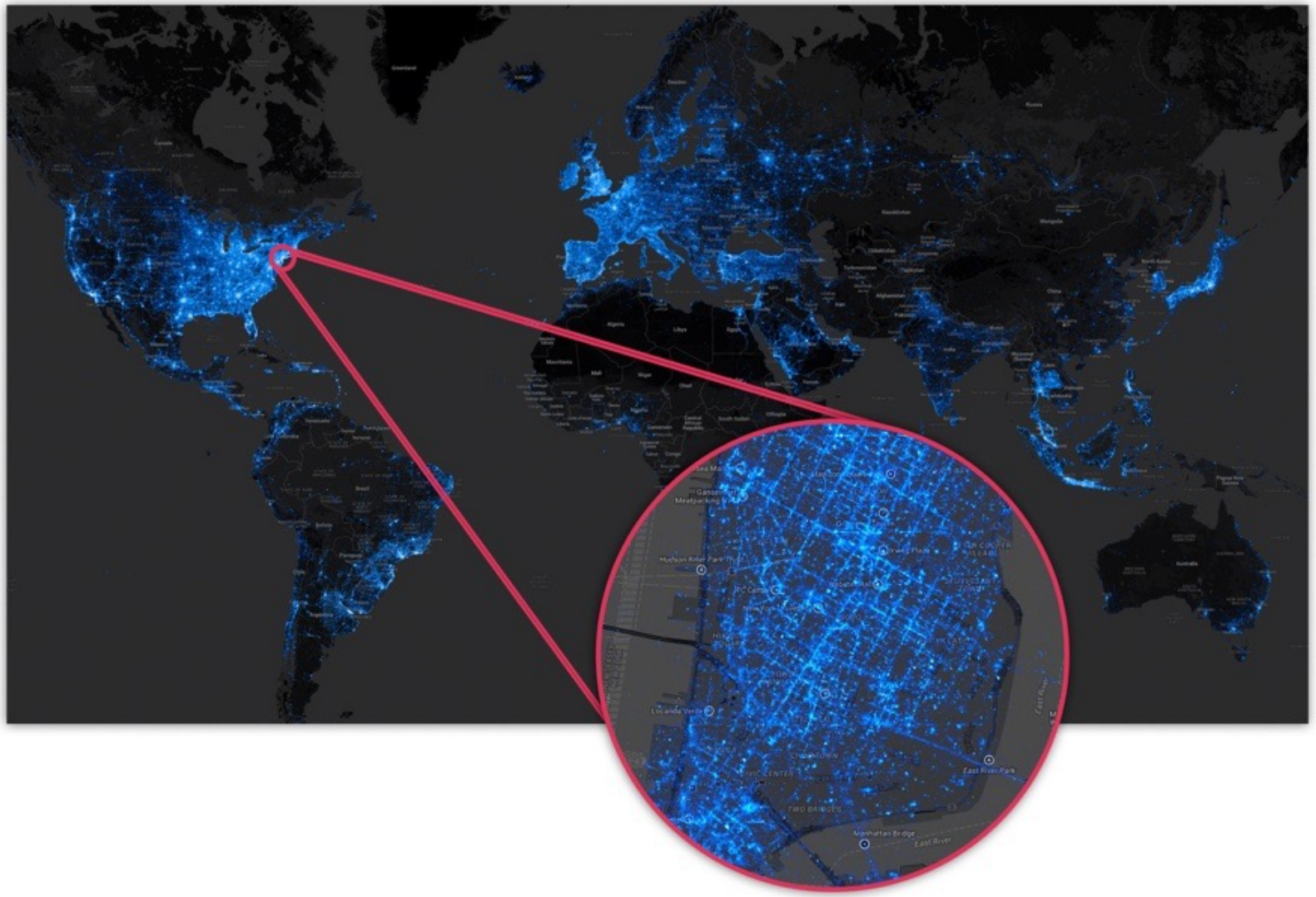
概览+细节的具体方法：滚动

- 提供更大的虚拟屏幕，允许用户鼠标滚动至不同区域

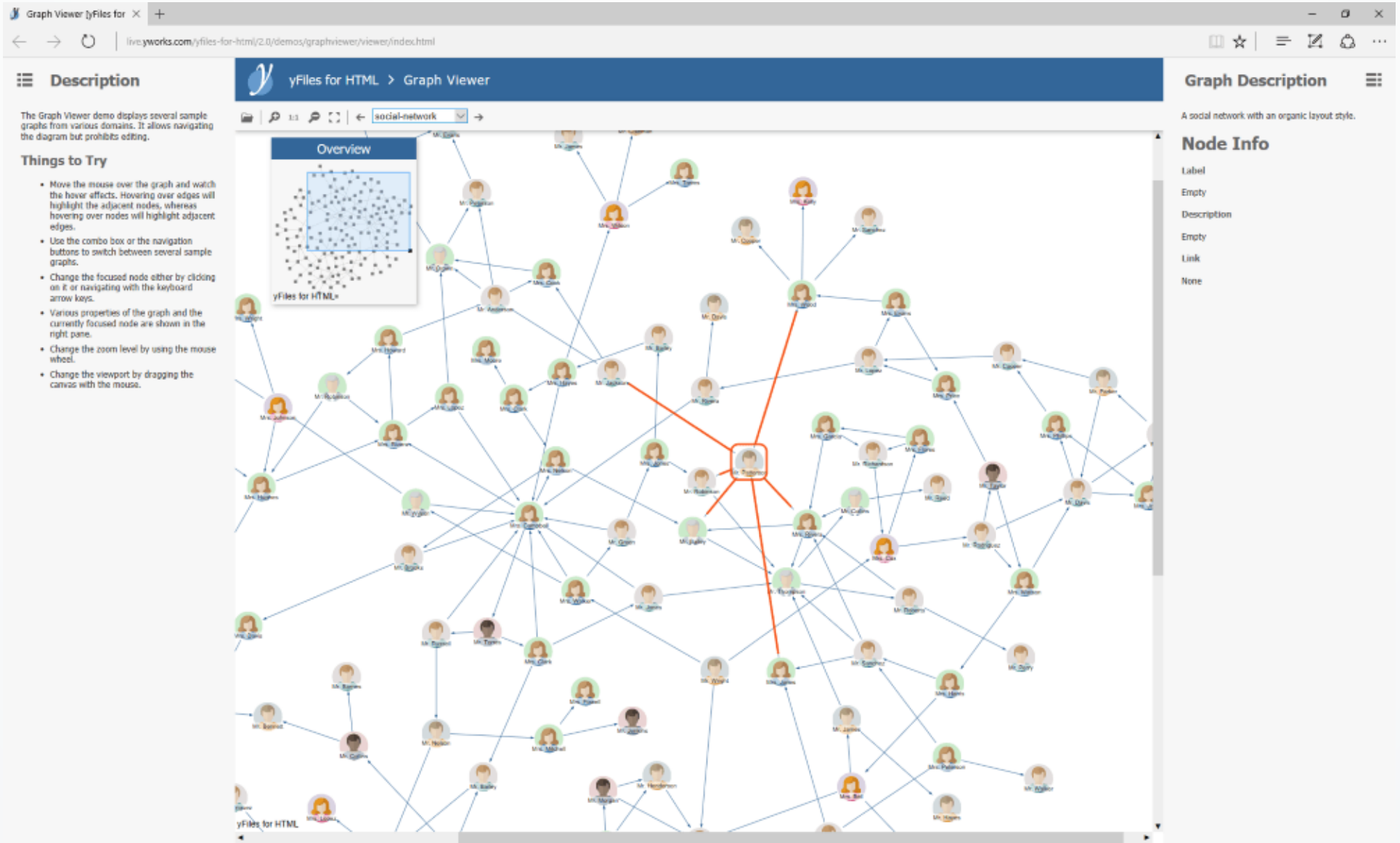
- 仍然存在的一些问题
  - 交互的流畅性仍需提高
  - 每次只能看到数据的一部分



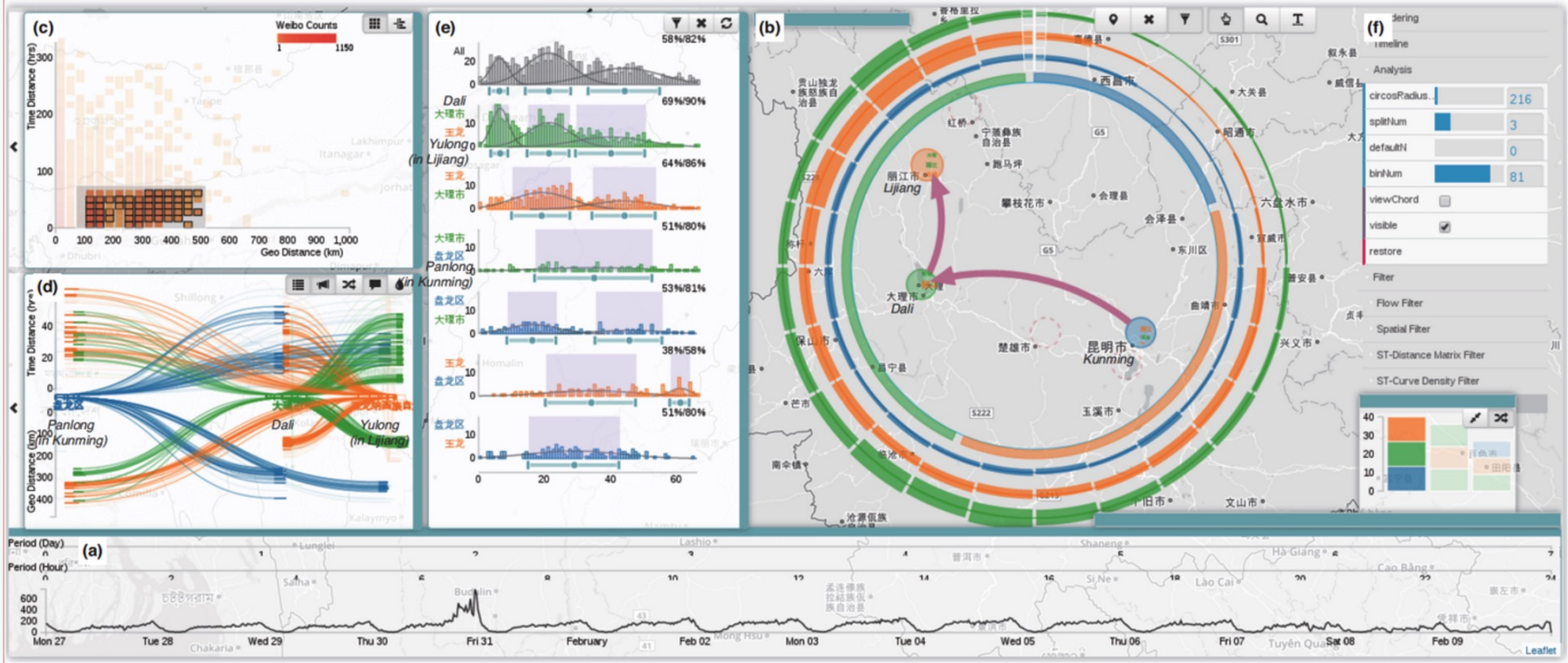
概览+细节的案例



概览+细节的案例

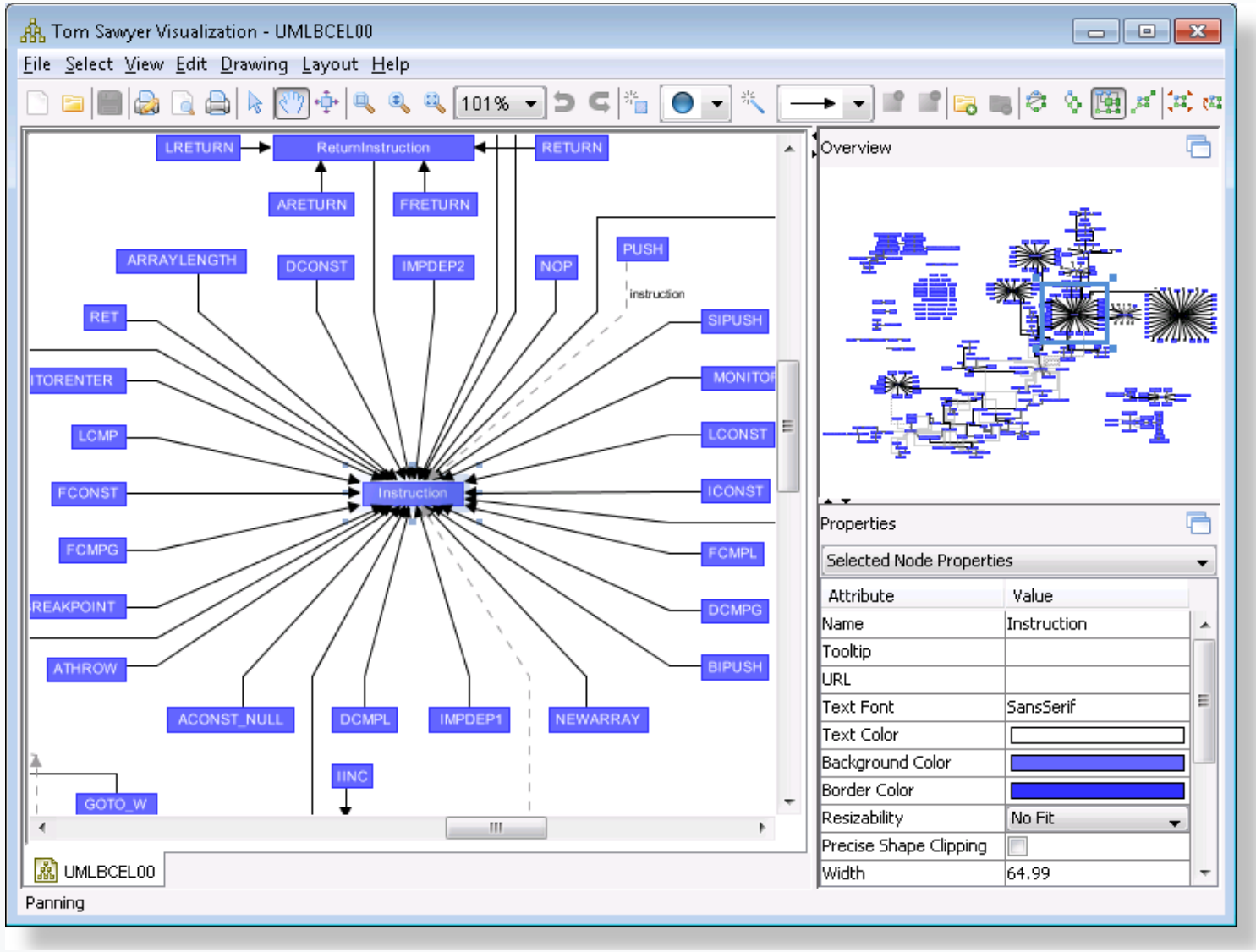

Graph Viewer |yFiles for
Description
The Graph Viewer demo displays several sample graphs from various domains. It allows navigating the diagram but prohibits editing.
Things to Try
Move the mouse over the graph and watch the hover effects. Hovering over edges will highlight the adjacent nodes, whereas hovering over nodes will highlight adjacent edges.
Use the combo box or the navigation buttons to switch between several sample graphs.
Change the focused node either by clicking on it or navigating with the keyboard arrow keys.
Various properties of the graph and the currently focused node are shown in the right pane.
Change the zoom level by using the mouse wheel.
Change the viewport by dragging the canvas with the mouse.
yFiles for HTML > Graph Viewer
social-network
Overview
Graph Description
A social network with an organic layout style.
Node Info
Label
Empty
Description
Empty
Link
None

概览+细节的案例



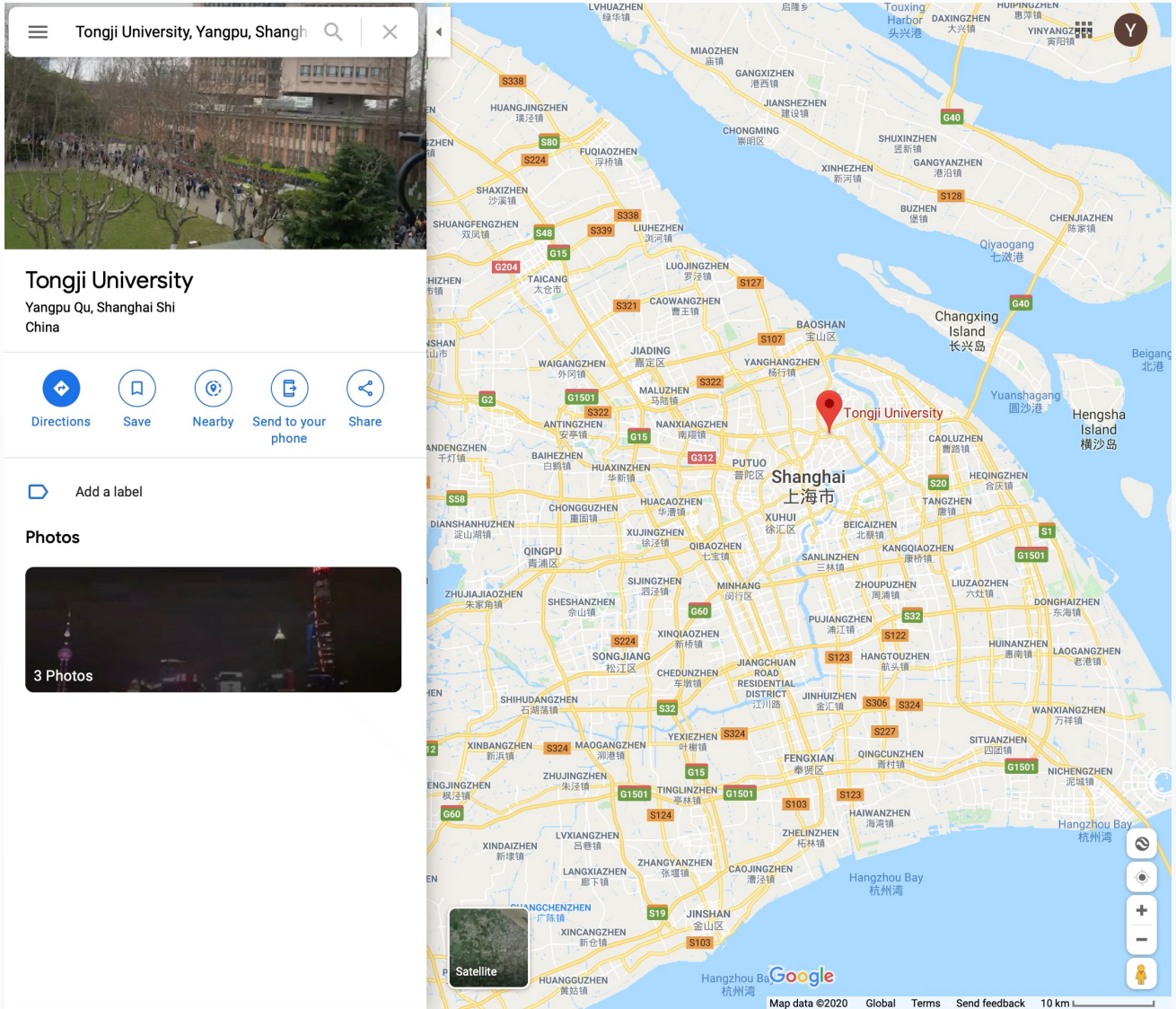
Interactive Visual Discovering of Movement Patterns from Sparsely Sampled Geo-tagged Social Media Data

概览+细节的案例

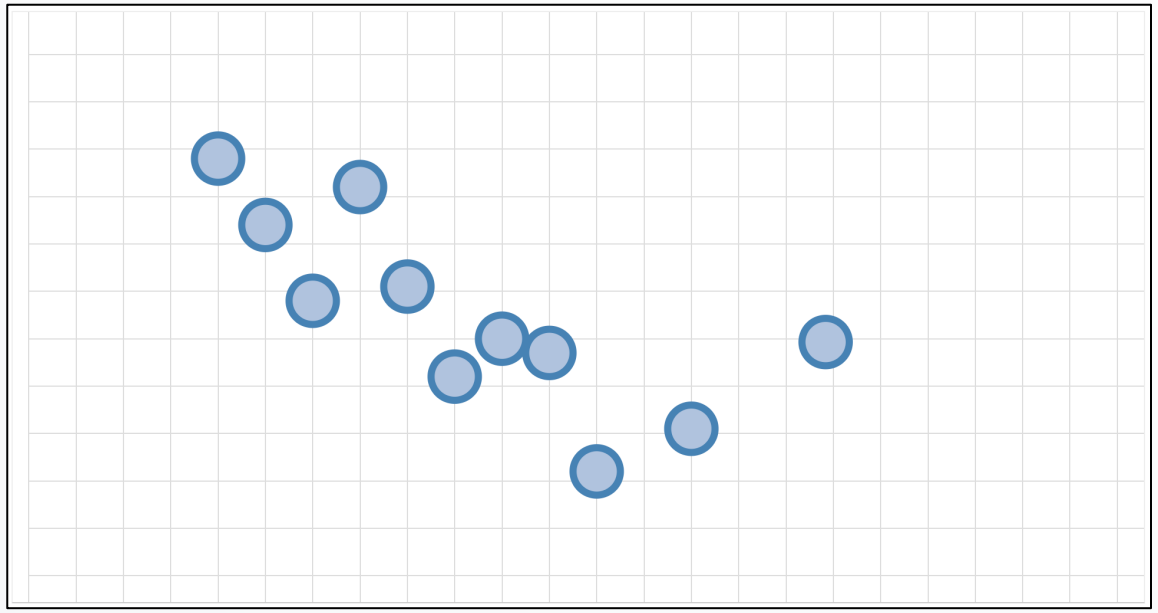

Tom Sawyer Visualization - UMLBCEL00
File Select View Edit Drawing Layout Help
101%
LRETURN
ReturnInstruction
RETURN
ARETURN
FRETURN
ARRAYLENGTH
DCONST
IMPDEP2
NOP
PUSH
instruction
RET
SIPUSH
ITORENTER
MONITOR
LCMP
LCONST
FCONST
Instruction
ICONST
FCMPG
FCMPL
REAKPOINT
DCMPG
ATHROW
BIPUSH
ACONST_NULL
DCMPL
IMPDEP1
NEWARRAY
IINC
GOTO_W
Overview
Properties
Selected Node Properties
Attribute
Value
Name
Instruction
Tooltip
URL
Text Font
SansSerif
Text Color
Background Color
Border Color
Resizability
No Fit
Precise Shape Clipping
Width
64.99
UMLBCEL00
Panning

概览+细节的具体方法：缩放和平移

- 缩放: 增加或删除像素来改变图片的尺寸
- 平移: 改变图片在窗口中显示的部分
- 例如: 在谷歌地图中查看地理信息

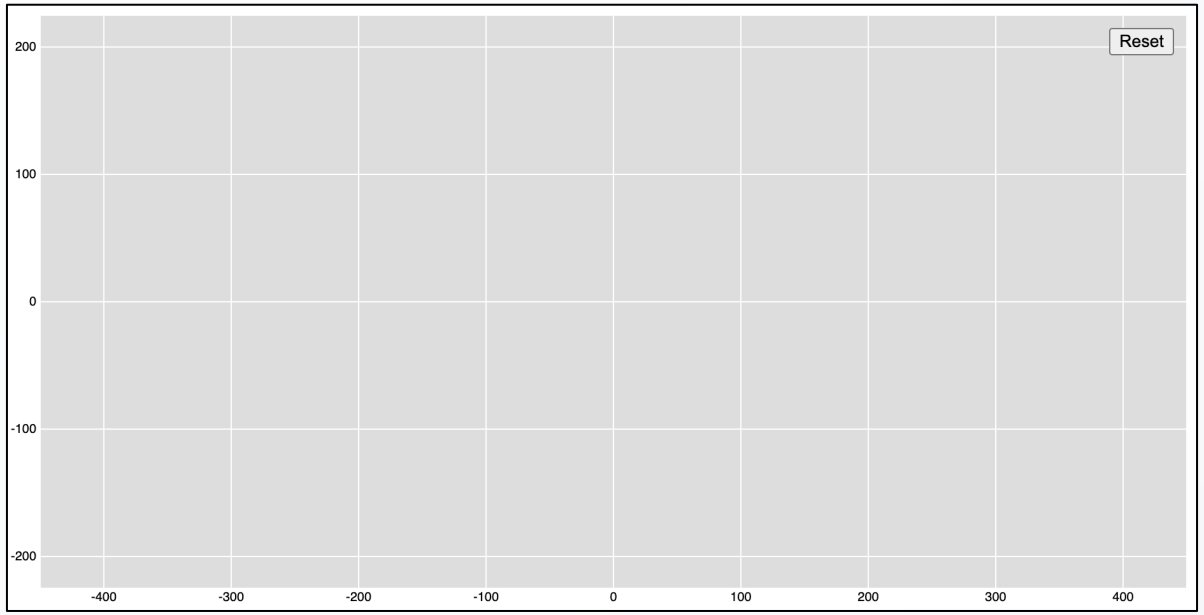


概览+细节的具体方法：缩放和平移



https://bl.ocks.org/mbostock/6123708

Graphic

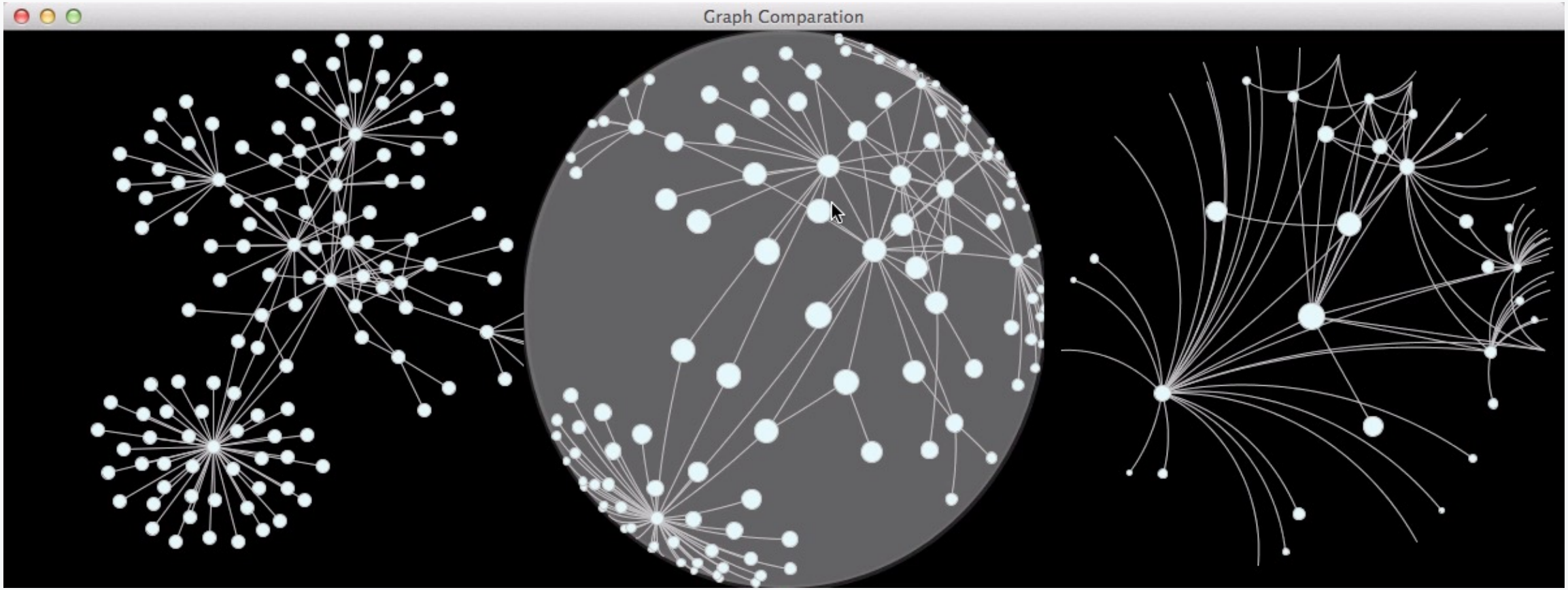


https://bl.ocks.org/mbostock/3892928

Semantic

交互范式2: 焦点+上下文（focus + context)

- 任务：显示焦点的细节信息，同时显示焦点周边的信息



交互范式2: 焦点+上下文（focus + context)

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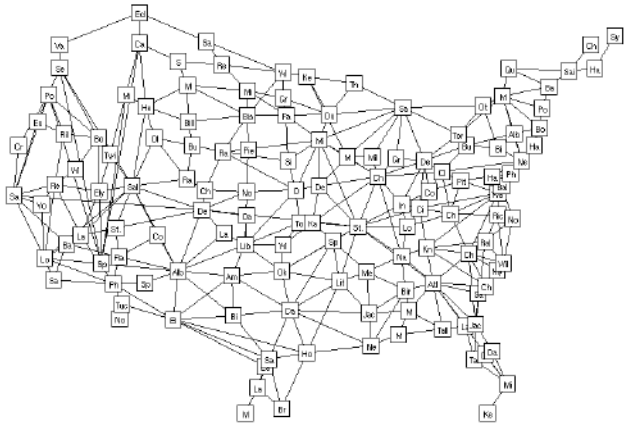


Figure 1: A graph with 134 vertices and 338 edges. The vertices represent major cities in the United States, and the edges represent paths between neighboring cities. (Typically, the edges would be annotated with the distance and driving time between the cities.) The *a priori importance* value assigned to each vertex is proportional to the population of the corresponding city. Fisheye views of this graph appear in Figures 2–6

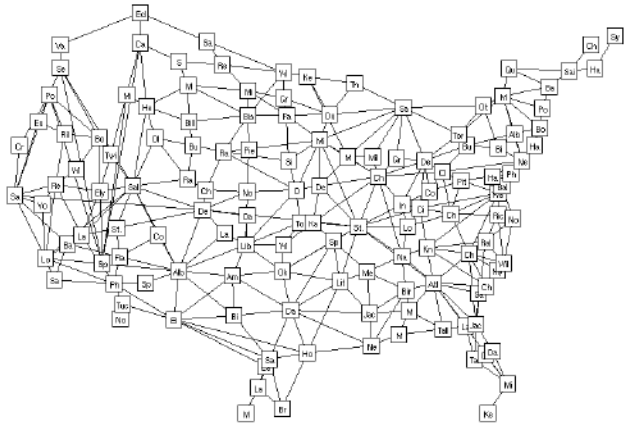
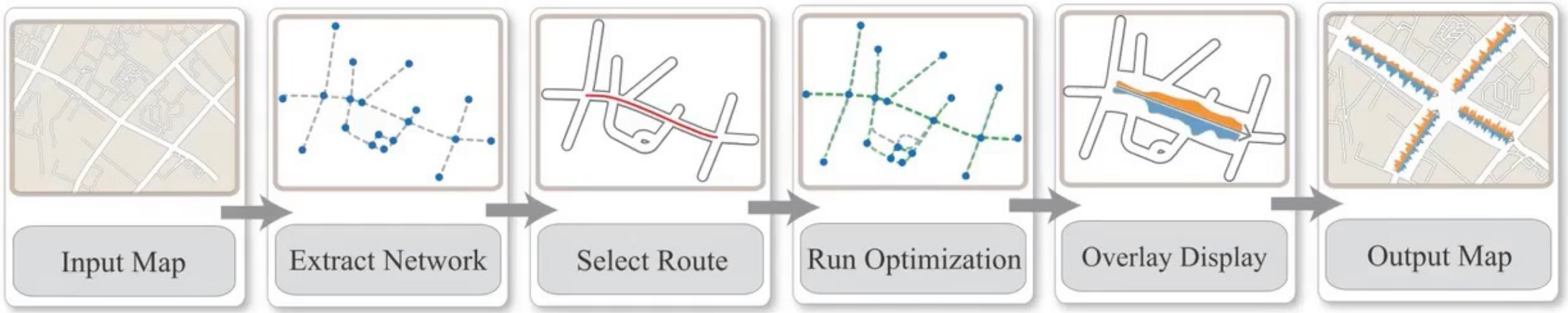


Figure 1: A graph with 134 vertices and 338 edges. The vertices represent major cities in the United States, and the edges represent paths between neighboring cities. (Typically, the edges would be annotated with the distance and driving time between the cities.) The *a priori importance* value assigned to each vertex is proportional to the population of the corresponding city. Fisheye views of this graph appear in Figures 2–6

iSphere: Focus+Context Sphere Visualization for Interactive Large Graph Exploration

Fan Du, Nan Cao, Yu-Ru Lin
Panpan Xu, and Hanghang Tong

System Overview



焦点+上下文的具体方式： 可视化形变

- 通过压缩可视化视图中不重要的部分，为重点内容留出更多的展示空间

- 基本原理
  - 形变函数：决定了形变的方法
  - 放大函数：决定了形变的尺度

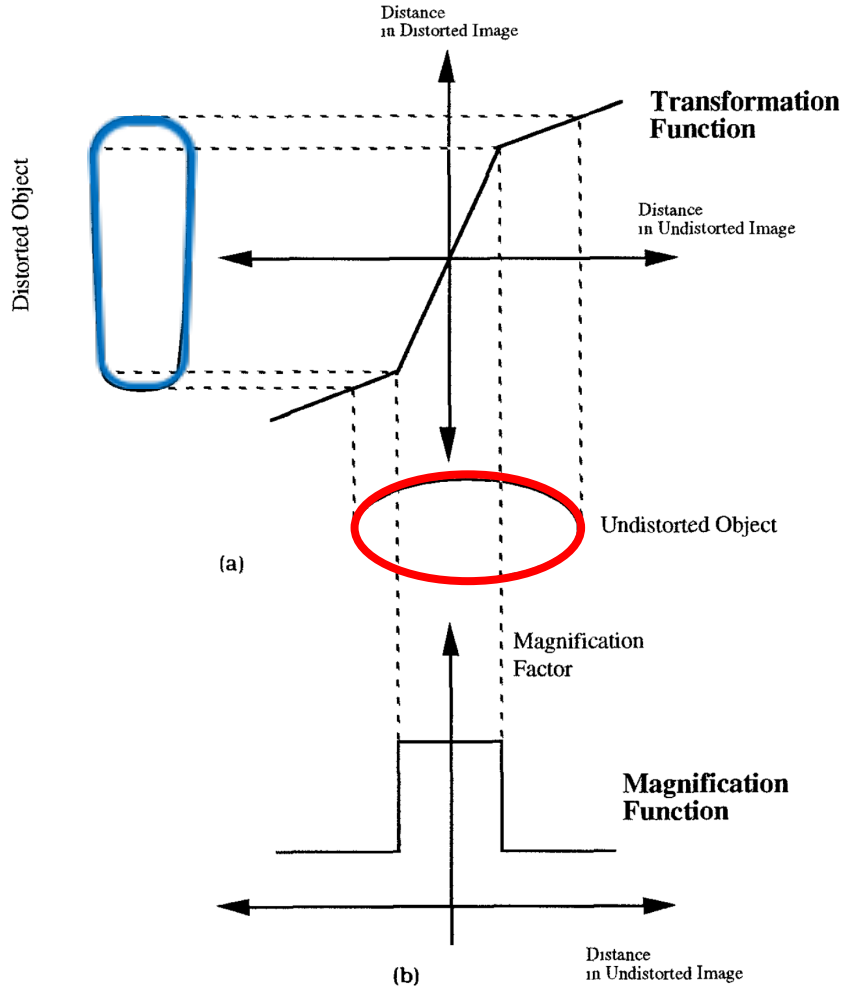
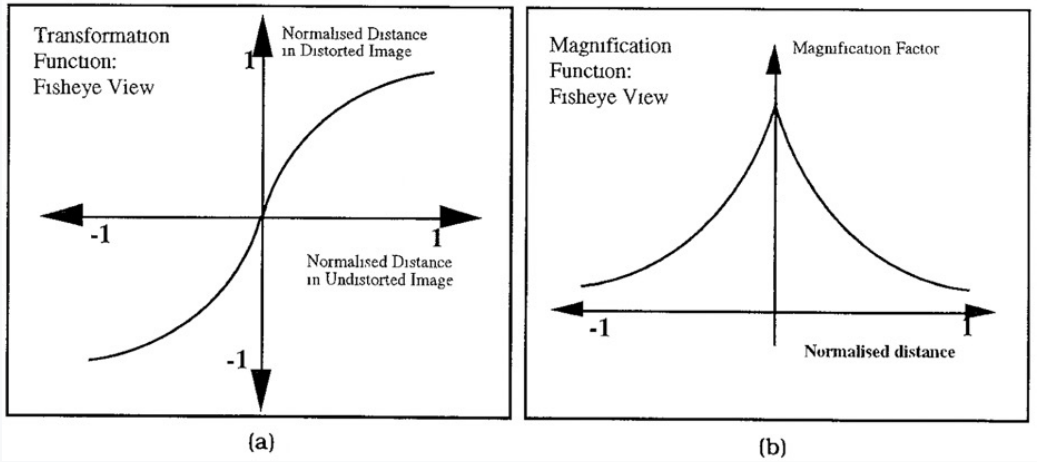


Fig. 3. (a) The transformation of an elliptic object by applying the transformation function of a Bifocal Display in one dimension; (b) the corresponding magnification function of the Bifocal Display.

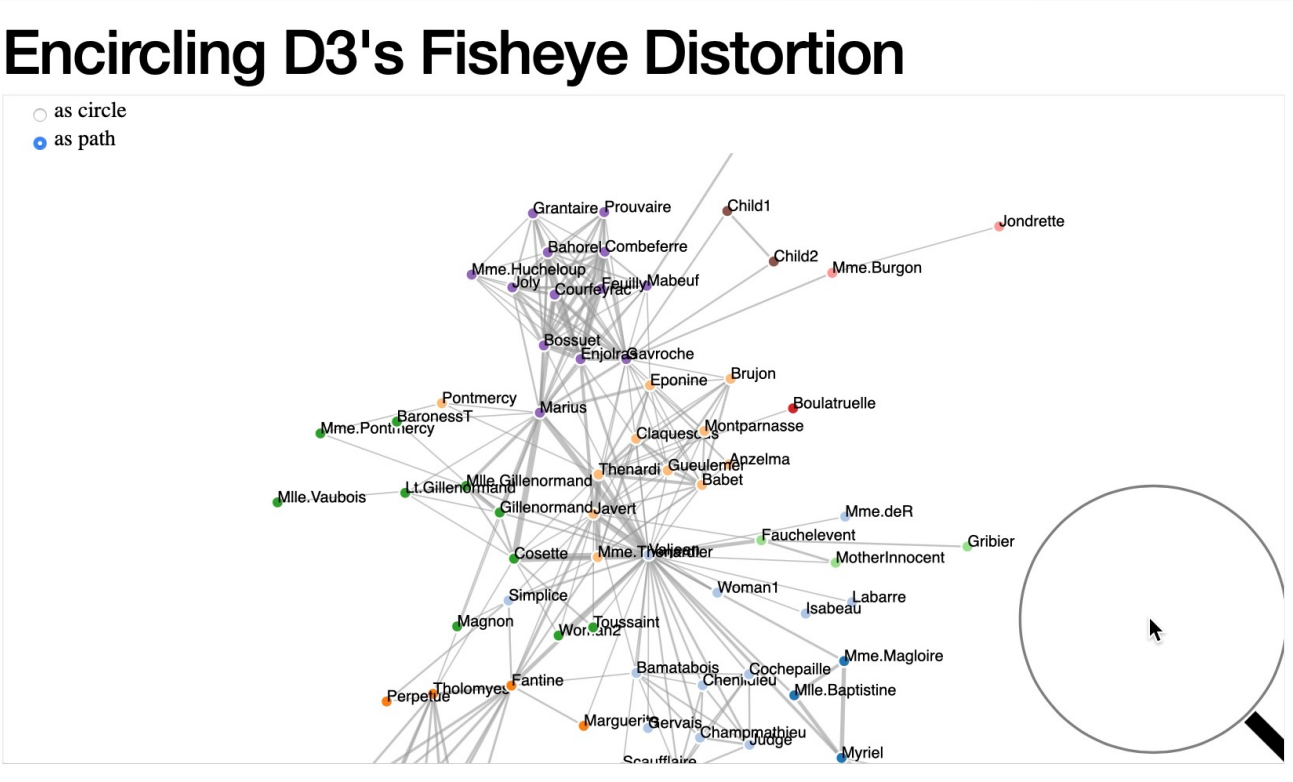
焦点+上下文的具体方式： 可视化形变

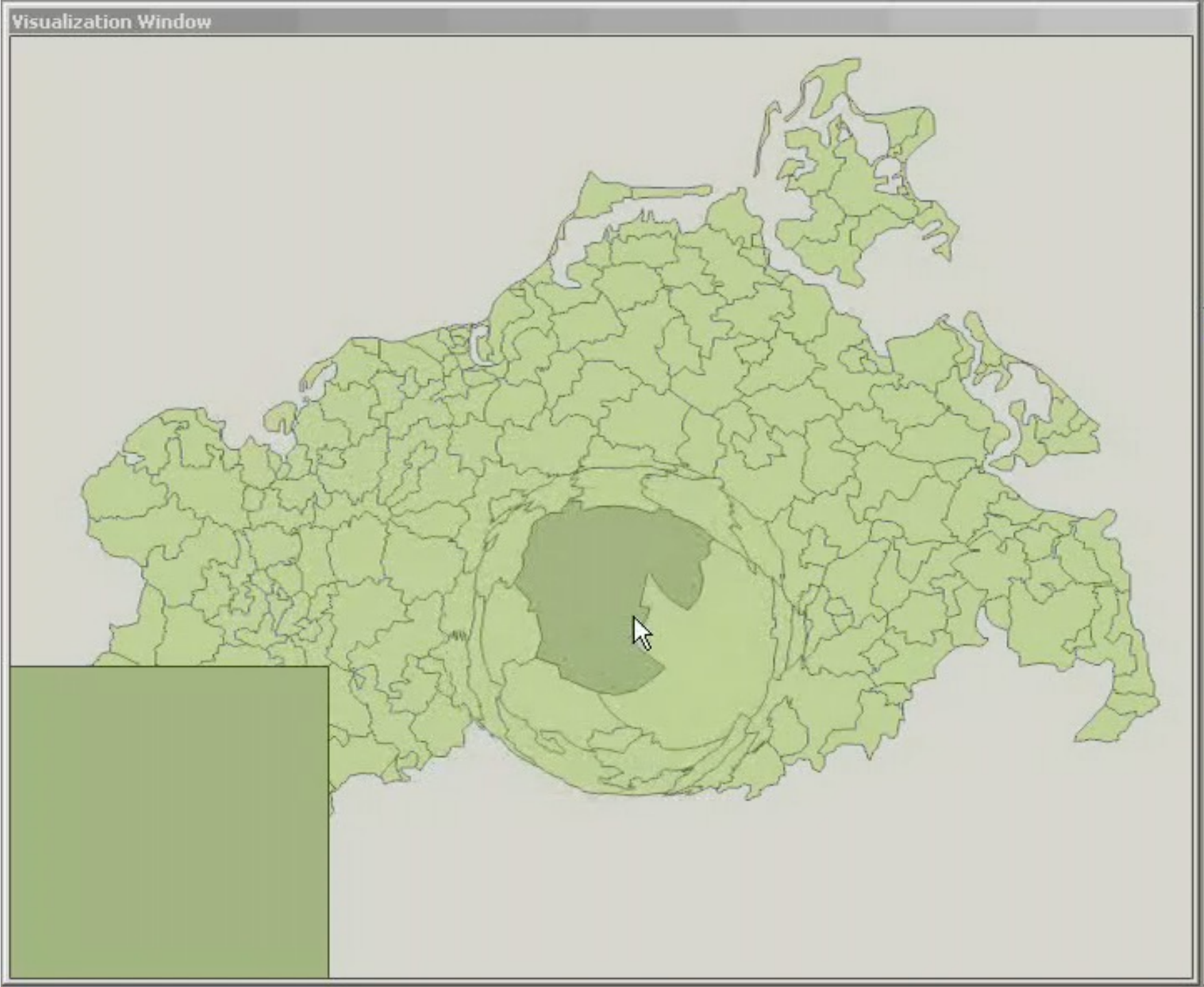
- 鱼眼形变



形变函数　　放大函数

$$T(x) = \frac{(d+1)x}{(dx+1)} \quad \text{and} \quad M(x) = \frac{(d+1)}{(dx+1)^2}$$





TableViewForm

Tables: erkrankunger

	periode	periodennr	gebietsnr	krankheits	ana
	tag	1998001	13	12	
	tag	1998001	13	11	
	tag	1998001	13	10	
	tag	1998001	13	9	
	tag	1998001	13	6	

Controls

Data Selection (I) | Data Selection (II) | Parameters

Drawing

Map3D.PencilDrawing

Maximum Type

AttributeMaximum

Keep Icon Orientation

Keep Icon Orientation

Lens Enabled

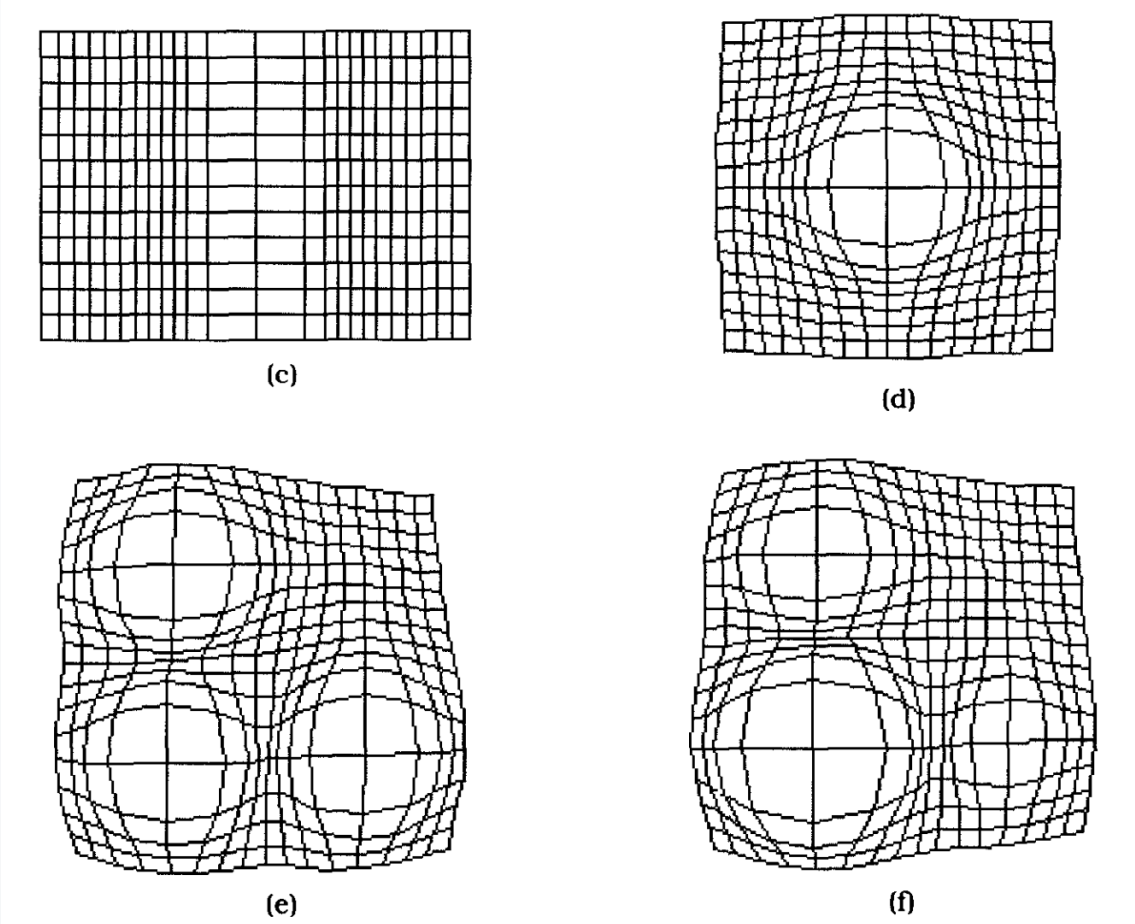
Lens Enabled

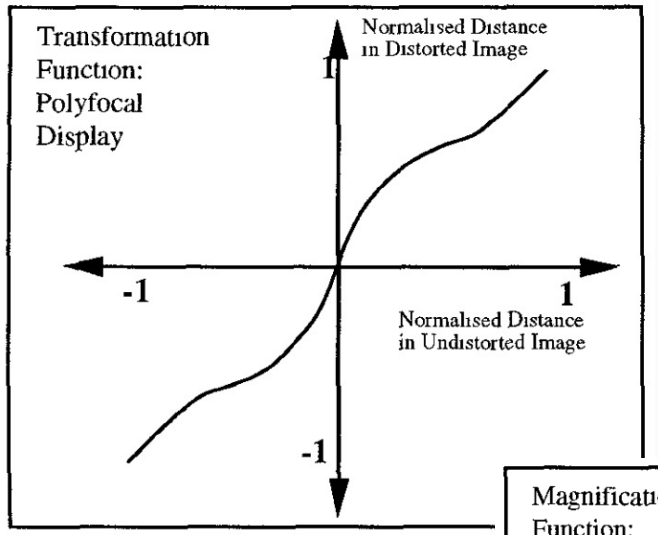
Lens Magnification

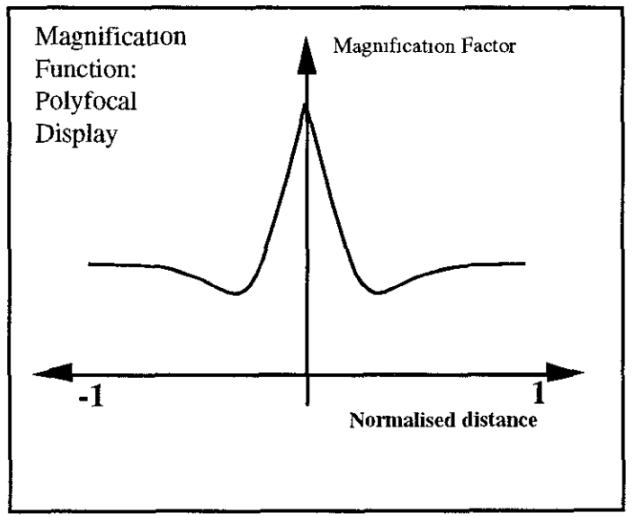
Lens Scope


abel (2)
abel (11)
abel (6)
albert, einstein, autobiography (2)
brahe, tycho (3)
crazy, scientist (2)
einstein, pcs (3)
famous, german, women (3)
famous, physics, scientists (4)
father
Fisheye Tree Views
for, what, did, einstein, win, his, 1st, nobel, priz
galileo, galilee (2)
ptolmey (2)
1954, dacron
1954, dacron (18)
1954, dacron (15)
1954, dacron (10)
death, of, albert, einstein (5)
3

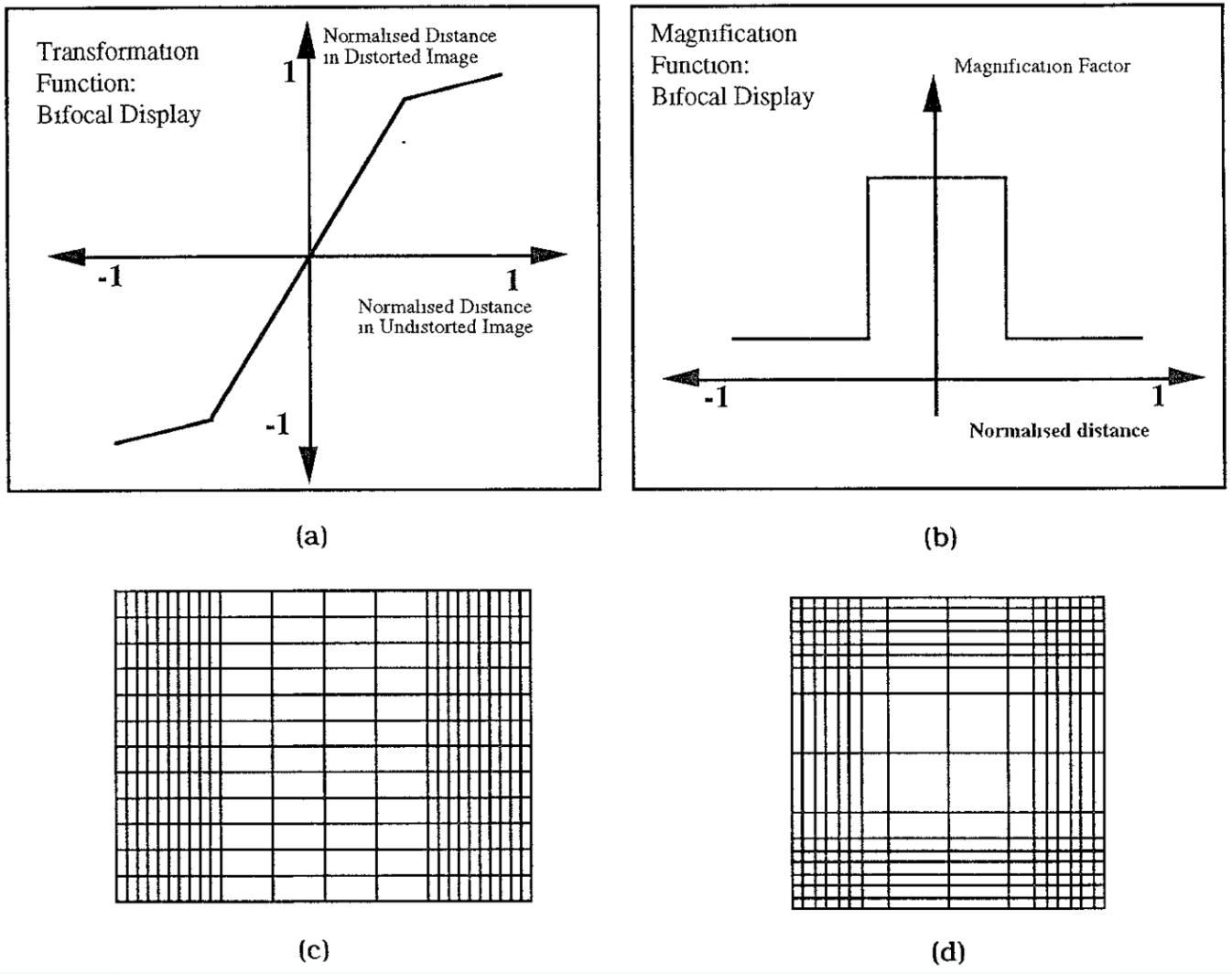
Polyfocal Projection

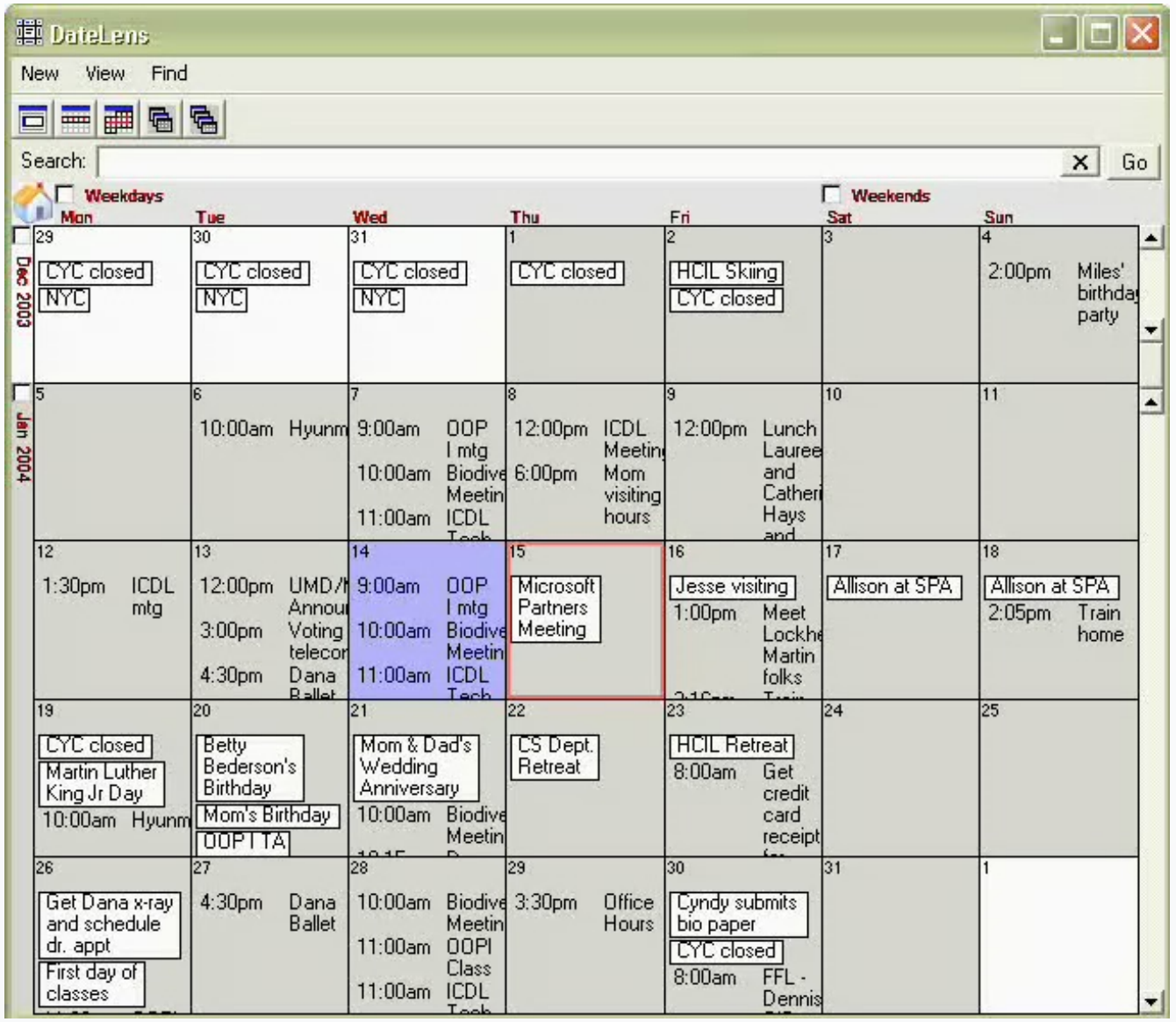






Bifocal Display




DateLens
New
View
Find
Search:
Go
Weekdays
Weekends
Mon
Tue
Wed
Thu
Fri
Sat
Sun
Dec 2003
Jan 2004
29
CYC closed
NYC
30
CYC closed
NYC
31
CYC closed
NYC
1
CYC closed
2
HCIL Skiing
CYC closed
3
4
2:00pm
Miles' birthday party
5
6
10:00am Hyunm
7
9:00am OOP
I mtg
10:00am Biodive
Meetin
11:00am ICDL
8
12:00pm ICDL
Meetin
6:00pm Mom
visiting
hours
9
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Lauree
and
Catheri
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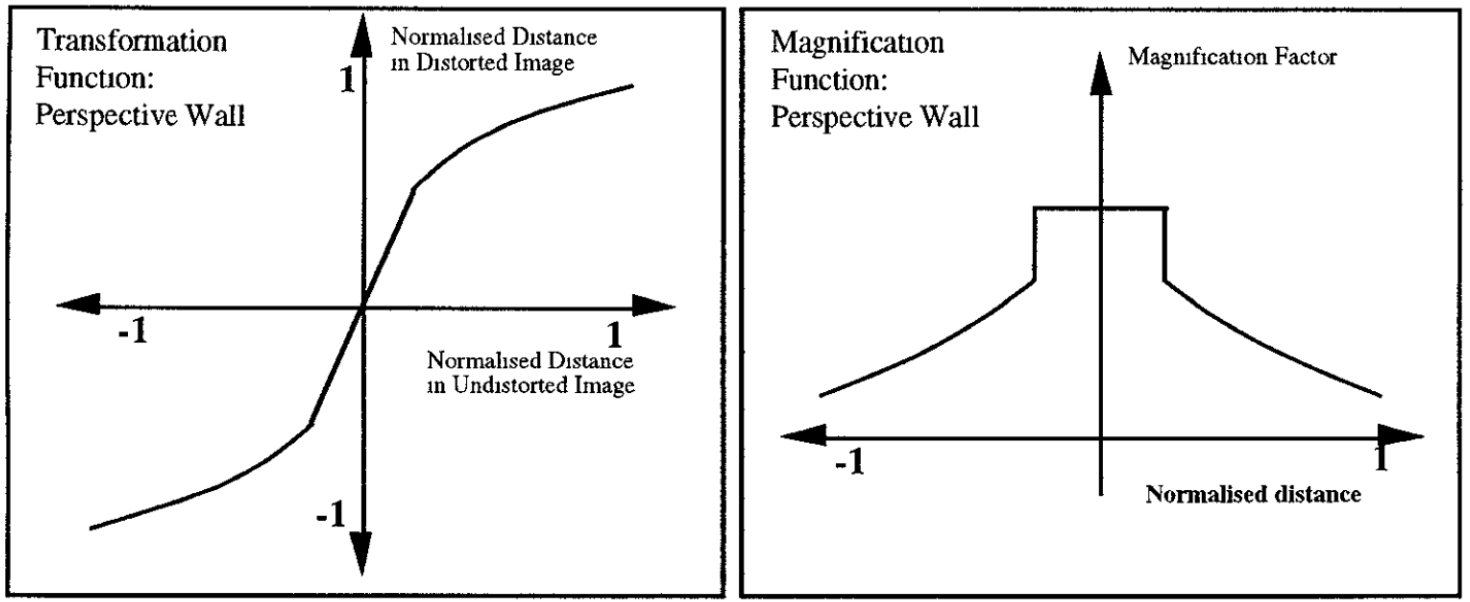
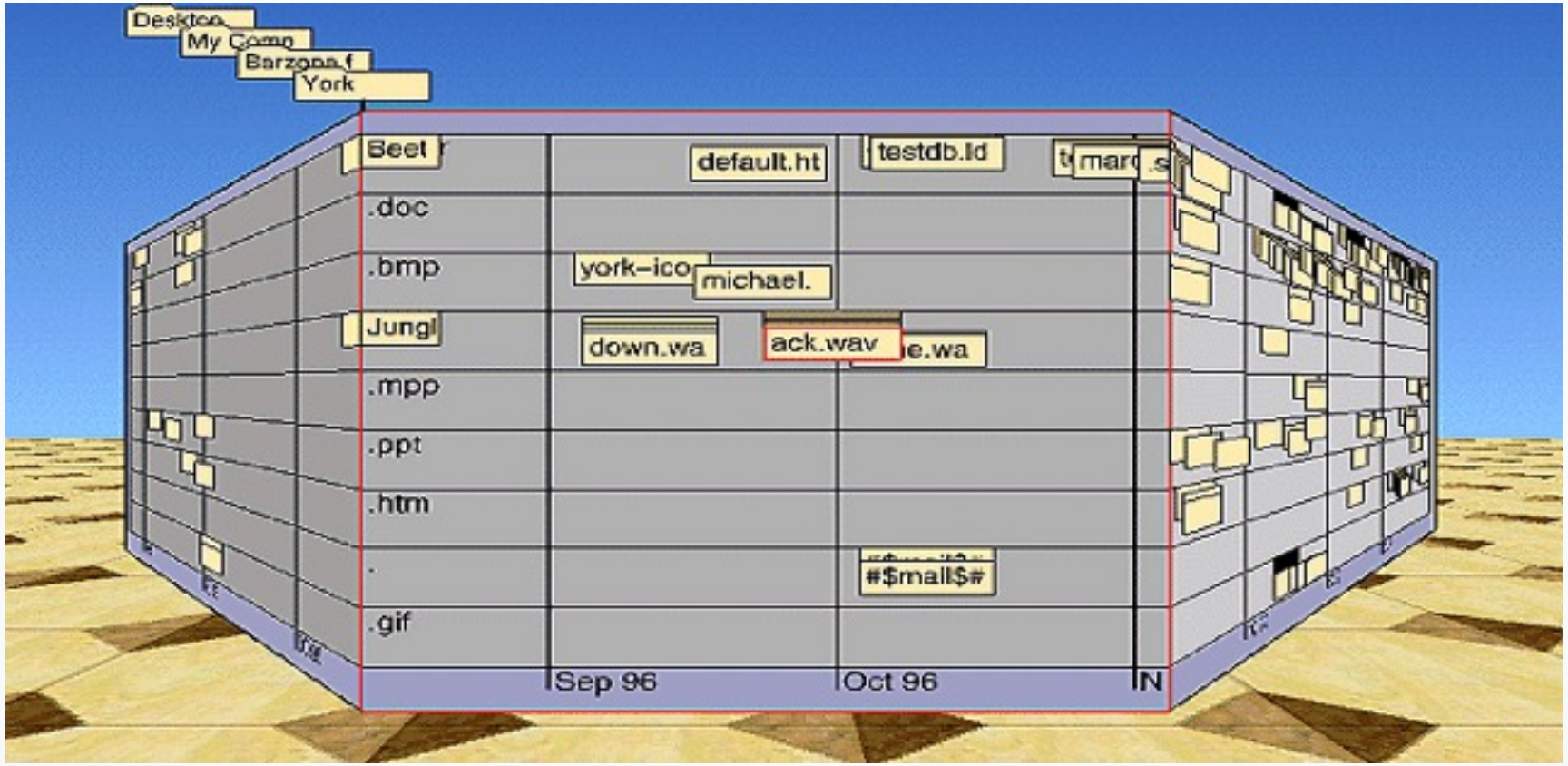
and
10
11
12
1:30pm ICDL
mtg
13
12:00pm UMD/
Annou
3:00pm Voting
telecor
4:30pm Dana
Ballet
14
9:00am OOP
I mtg
10:00am Biodive
Meetin
11:00am ICDL
15
Microsoft Partners Meeting
16
Jesse visiting
1:00pm Meet
Lockhe
Martin
folks
17
Allison at SPA
18
Allison at SPA
2:05pm Train
home
19
CYC closed
Martin Luther King Jr Day
10:00am Hyunm
20
Betty Bederson's Birthday
Mom's Birthday
OOP I TA
21
Mom & Dad's Wedding Anniversary
10:00am Biodive
Meetin
22
CS Dept. Retreat
23
HCIL Retreat
8:00am Get
credit
card
receipt
24
25
26
Get Dana x-ray and schedule dr. appt
First day of classes
27
4:30pm Dana
Ballet
28
10:00am Biodive
Meetin
11:00am OOPI
Class
11:00am ICDL
29
3:30pm Office
Hours
30
Cyndy submits bio paper
CYC closed
8:00am FFL -
Dennis
31
1

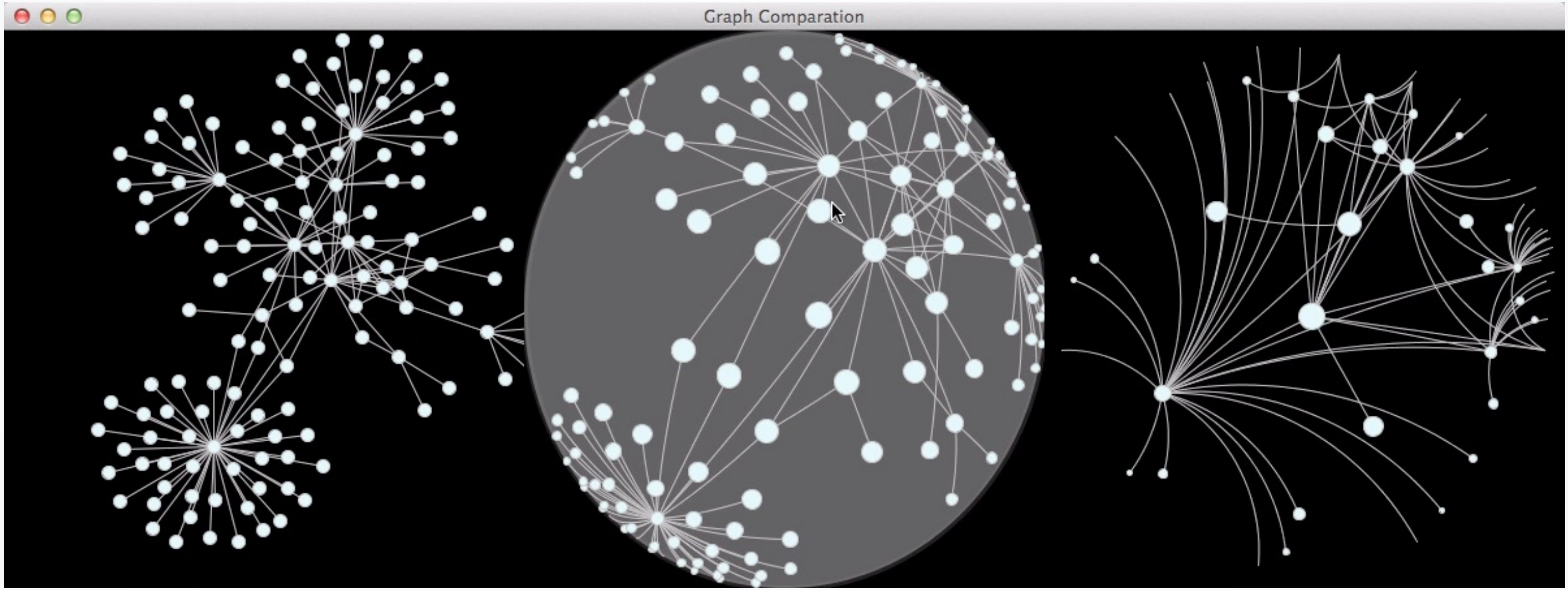
Perspective Wall





Perspective Wall

基于几何变换的焦点+上下文技术



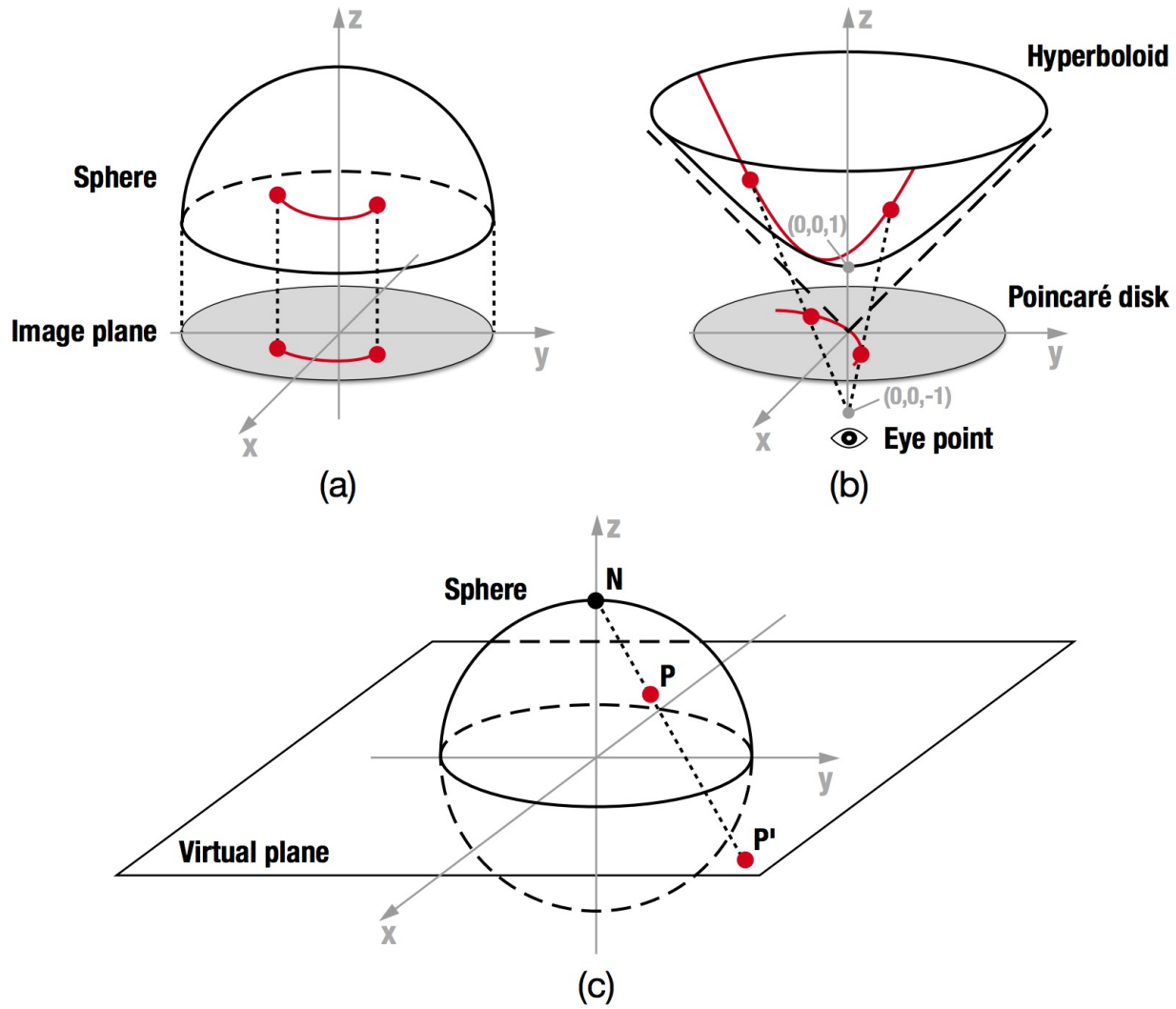
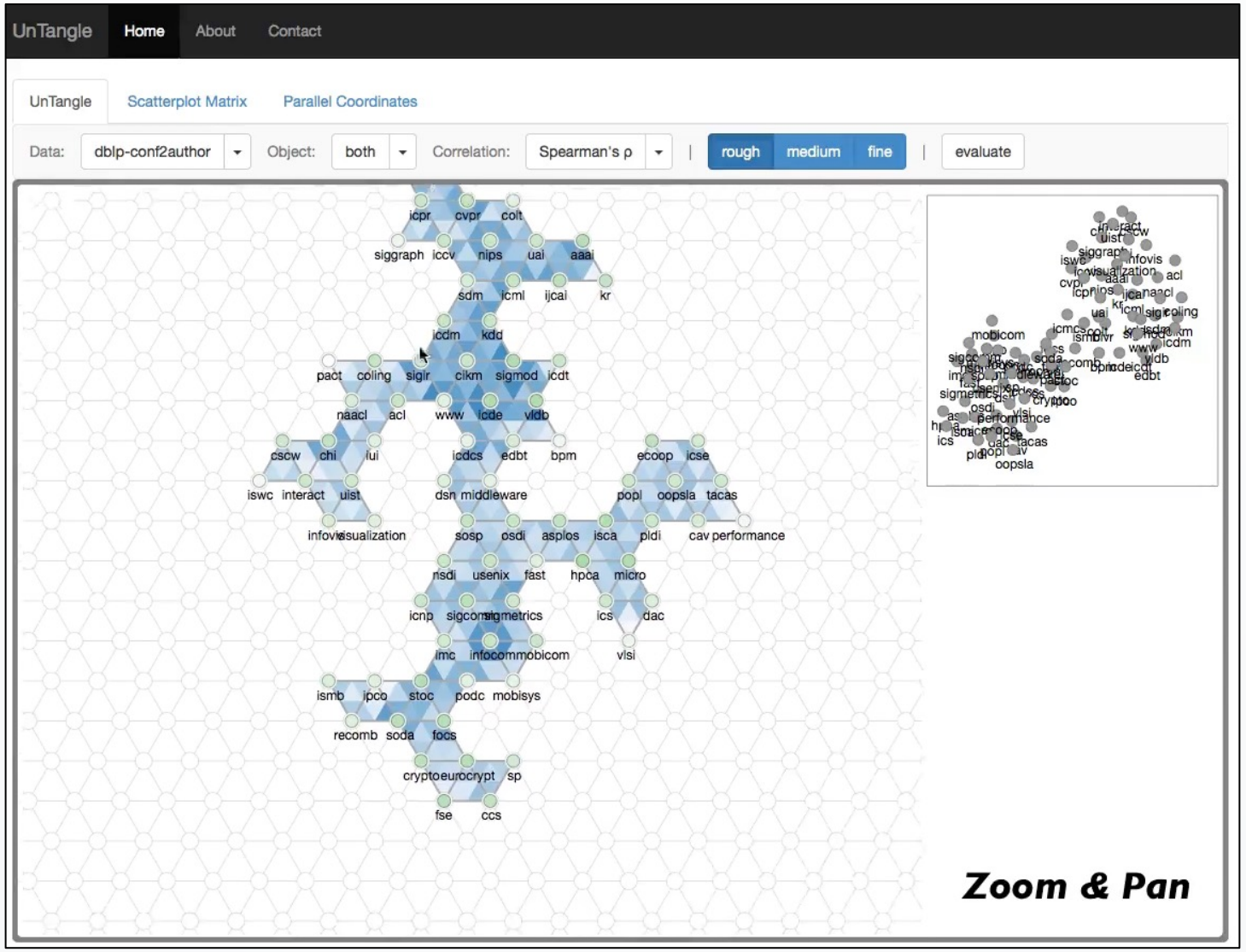


Figure 2. Illustrations of (a) the orthogonal projection from a sphere to a Euclidean plane, (b) the perspective projection from a hyperboloid surface to the Poincaré disk, and (c) the conformal mapping from the Riemann Sphere to a virtual plane.

提问：底下的可视化系统中使用了哪些交互方式?

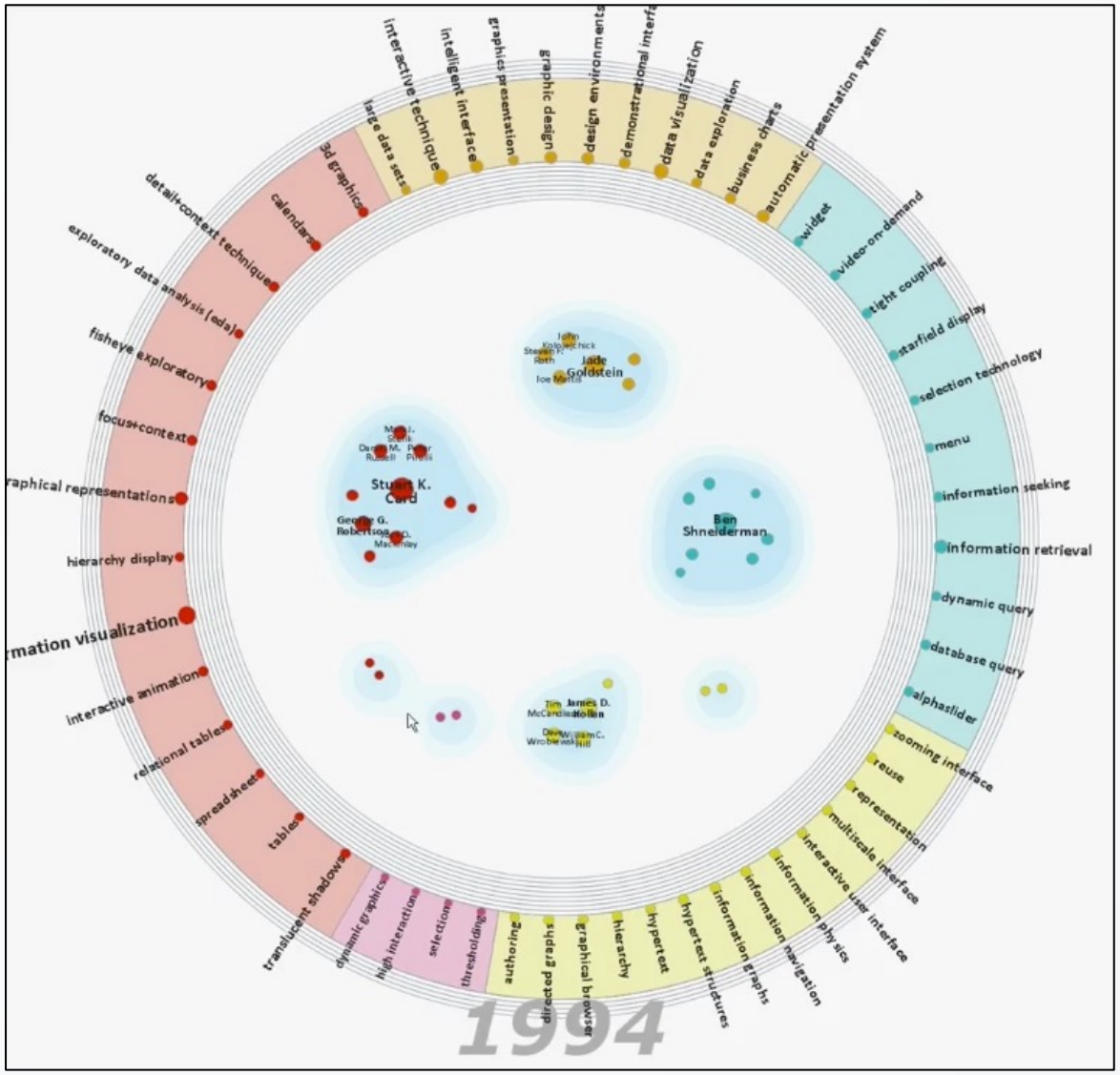


动画

- **可视化中的动画**
- 动画的设计原则
- 动画的实现方式

可视化中的动画

- 帮助理解数据的变化
  - 通过展示中间步骤和过渡，或者展示随时间变化数据收集情况

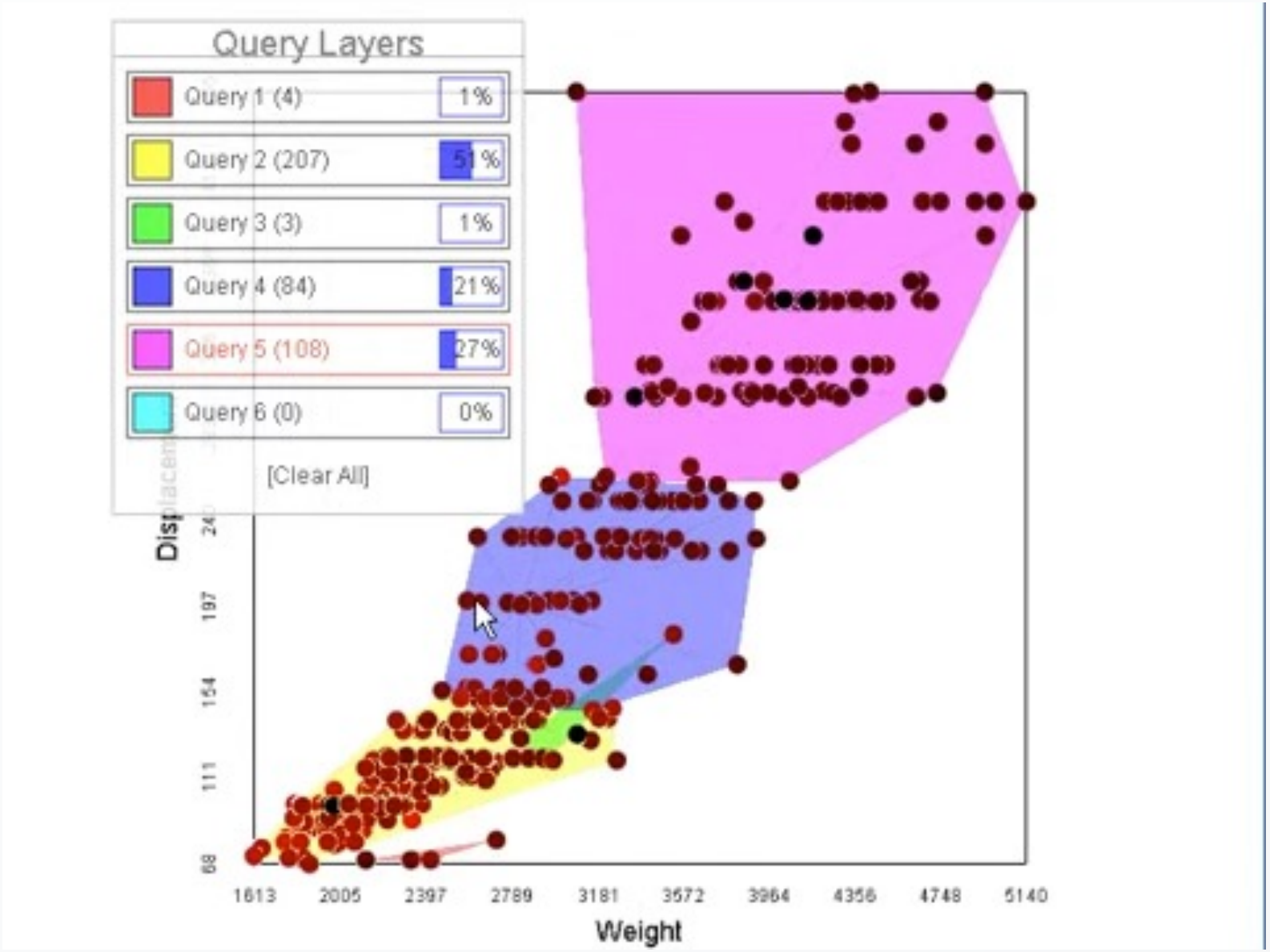


可视化中的动画

- 提升用户关注度
  - 提供新的视角，或者辅助用户更深入地查看数据

可视化中的动画

- 关联相关视图
  - 在两个视图之间实现平滑过渡



动画

- 可视化中的动画
- **动画的设计原则**
- 动画的实现方式

动画中的基本认知原则

- 运动物体的追踪原则
  - 用户难以同时分别追踪四个或者五个以上的运动物体

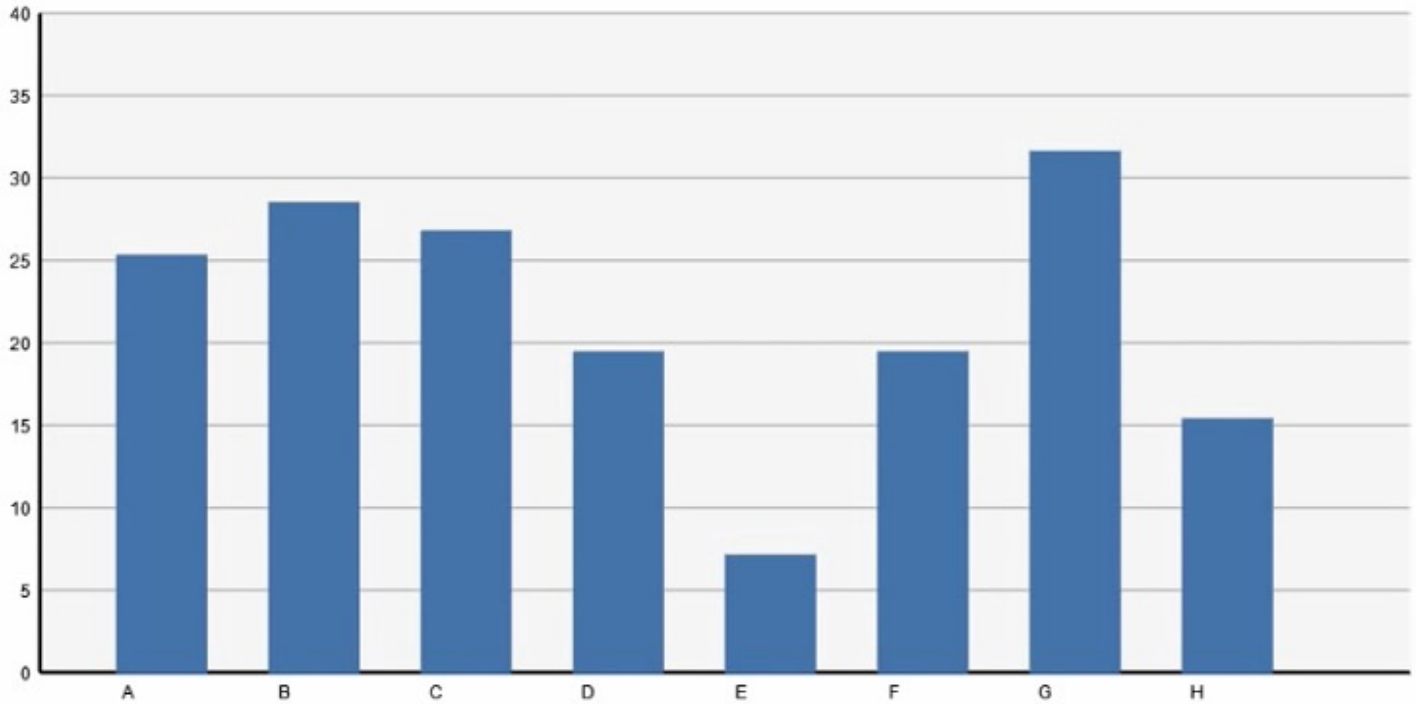
- 共同命运原则（common fate）
  - 用户能够识别朝着同一方向以同一速度运动的多个物体

动画的设计原则

- 阶段性原则
  - 一次只展示一个动画；如果需要同时展示多个动画，需要分阶段展示
- 兼容性原则
  - 动画必须与其载体，即所对应的可视化形式保持兼容
- 必要性原则
  - 只展示发生改变的数据，且动画的设计能让用户理解
- 合理性原则
  - 动画的每个步骤必须有具体的含义，动画的产生必须有明确的原因

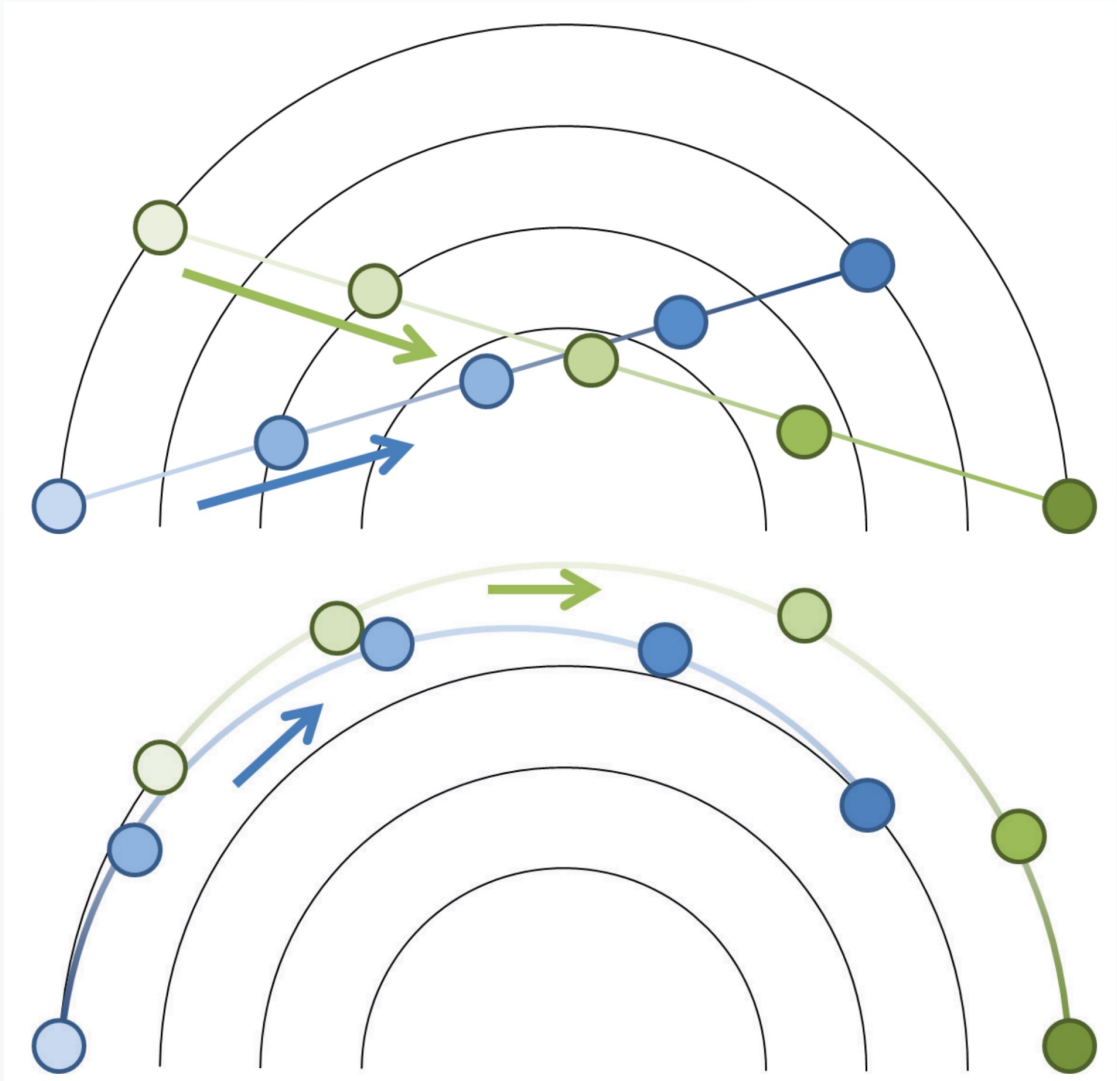
动画设计案例 1

- 阶段性
  - 不同时展示多个动画，即现阶段动画完成后再开始下一阶段的动画
- 必要性
  - 如果数据未发生改变，则不需要用动画表示
- 合理性
  - 动画的每个步骤必须有具体的含义，需要保留数据到可视化的合理映射



Animated Transitions in Statistical Data Graphics, Jeffrey Heer, George Robertson

动画设计案例 2



Animated Exploration of Graphs with Radial Layout

IEEE InfoVis 2001

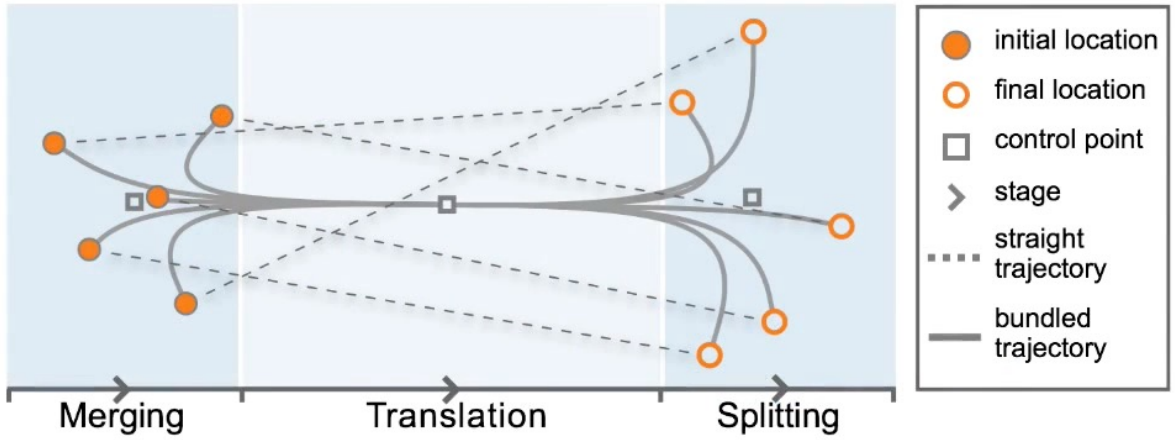
Ka-Ping Yee
Rachna Dhamija
Danyel Fisher
Marti Hearst

University of California, Berkeley

动画设计案例 3

- 基本思想：若多个物体朝着同一方向，则将他们的运动路径绑定在一起

- 遵循了共同命运原则



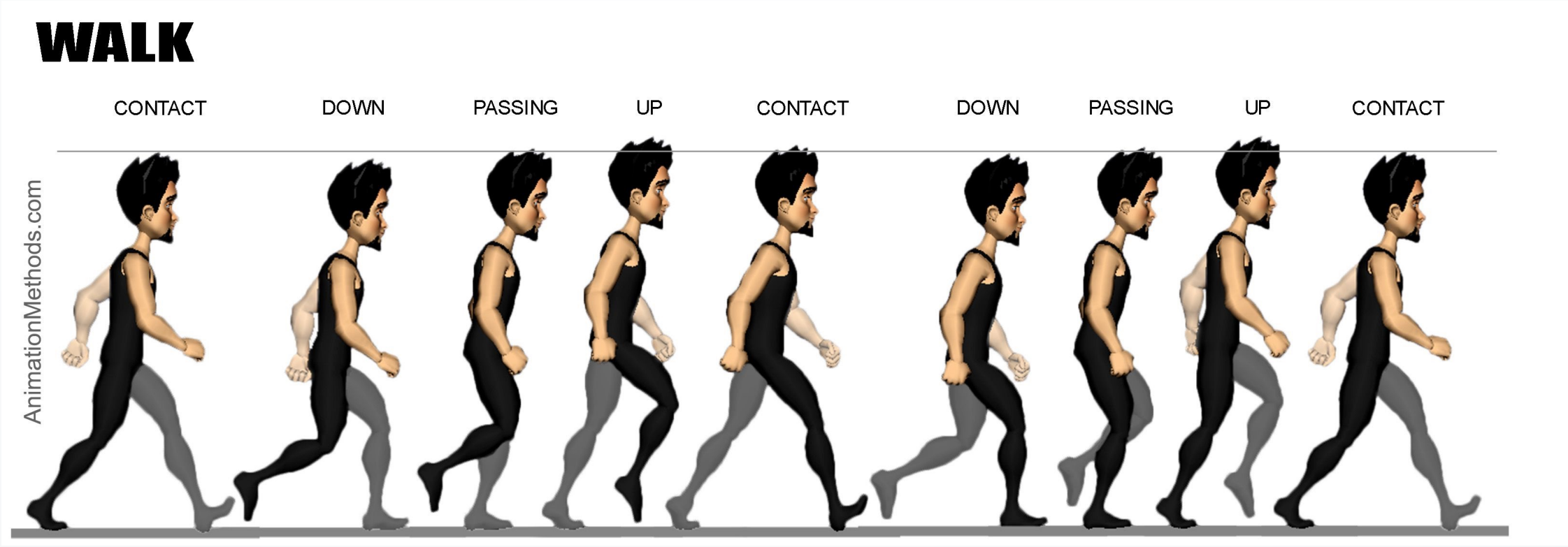
bundled trajectories

动画

- 可视化中的动画
- 动画的设计原则
- **动画的实现方式**

动画的实现方式

- 动画是通过一系列连续的逐渐的变化组成的



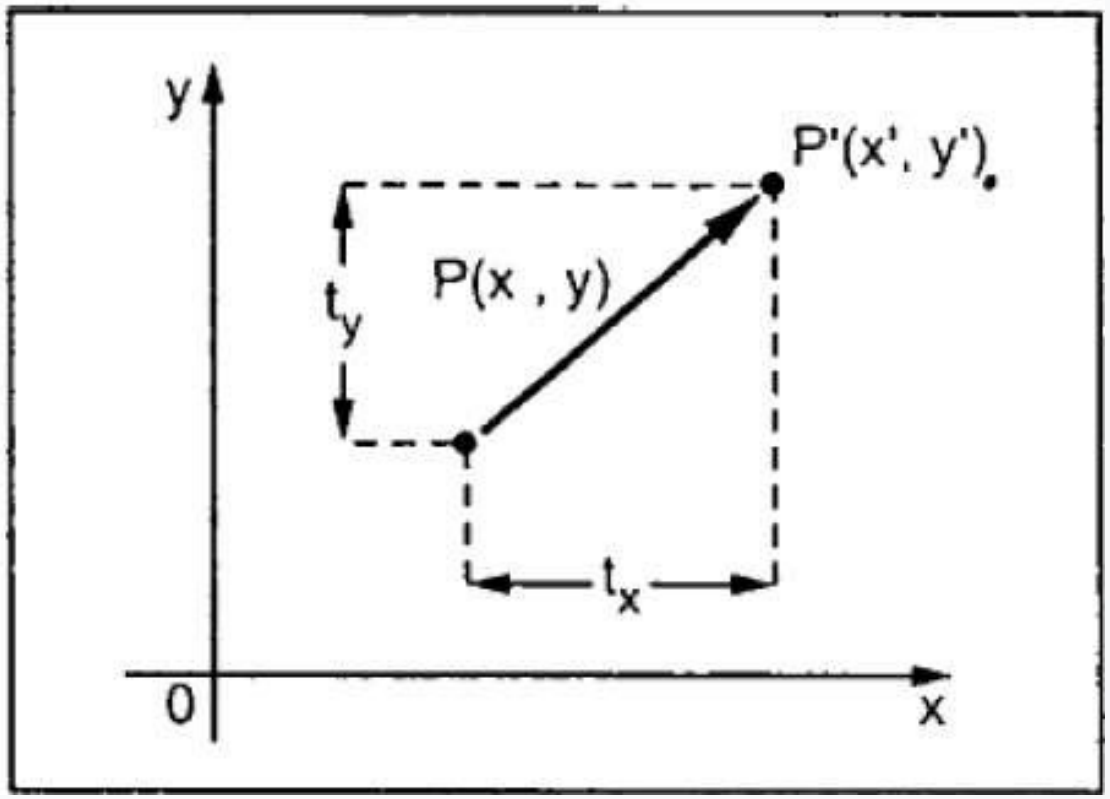
几何变换 （Transformation）

- 改变物体的可视化属性

  - 坐标位置： Translation （平移变换）
  - 方向：Rotation（旋转）
  - 大小：Scaling（缩放）
  - 形状：Sheering （倾斜） / Flipping（镜像） / Morphing（形变）

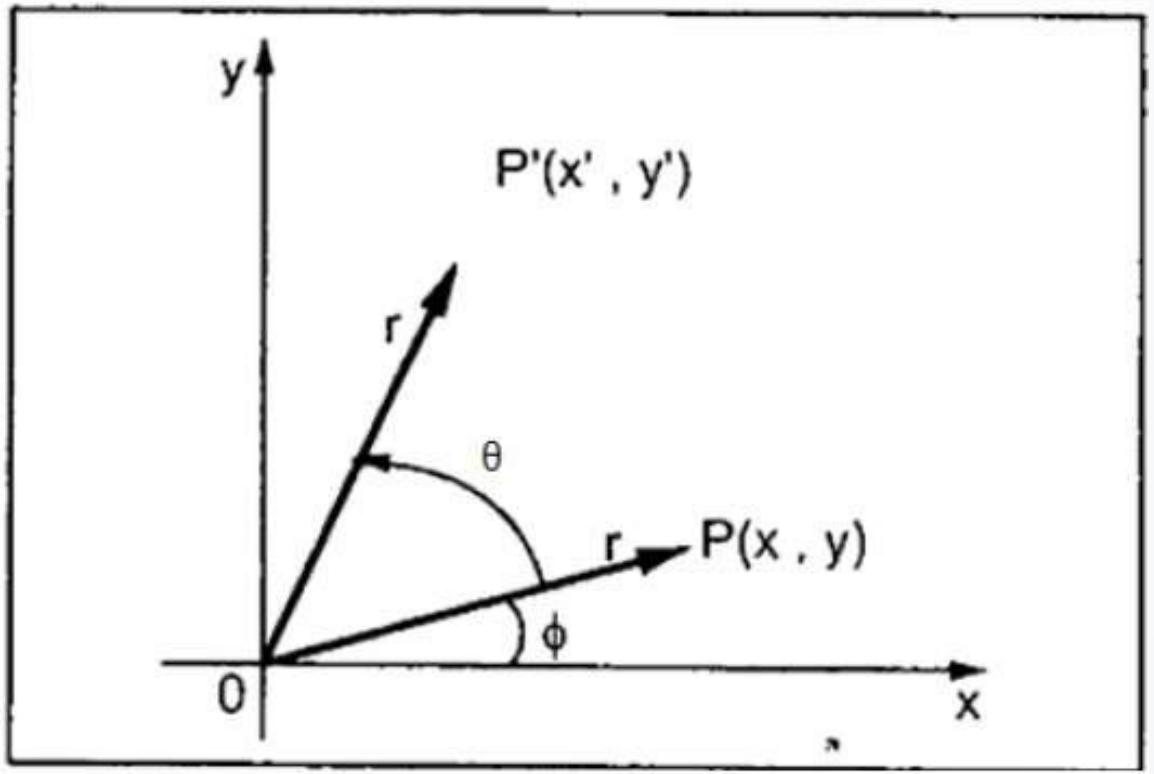
平移变换 （Translation）

- 将物体在空间中平移至另一位置
- 在二位空间中，平移可以通过在原坐标P (X, Y) 上平移坐标实现$T = (t_x, t_y)^T$
- $P' = P + T$



旋转变换 （Rotation）

- 将物体旋转一个角度 θ (theta)
- P(X, Y) is located at angle φ from the horizontal X coordinate with distance r from the origin
- Let us suppose you want to rotate it at the angle θ. After rotating P with angle θ, you will get a new point P’ (X’ , Y’).



旋转变换 （Rotation）

- Under standard trigonometric

$x=r\cos(\phi)$ (1)

$y=r\sin(\phi)$ (2)

$x'=r\cos(\phi+\theta)=r\cos(\phi)\cos(\theta)-r\sin(\phi)\sin(\theta)$

$y'=r\sin(\phi+\theta)=r\cos(\phi)\sin(\theta)+r\sin(\phi)\cos(\theta)$

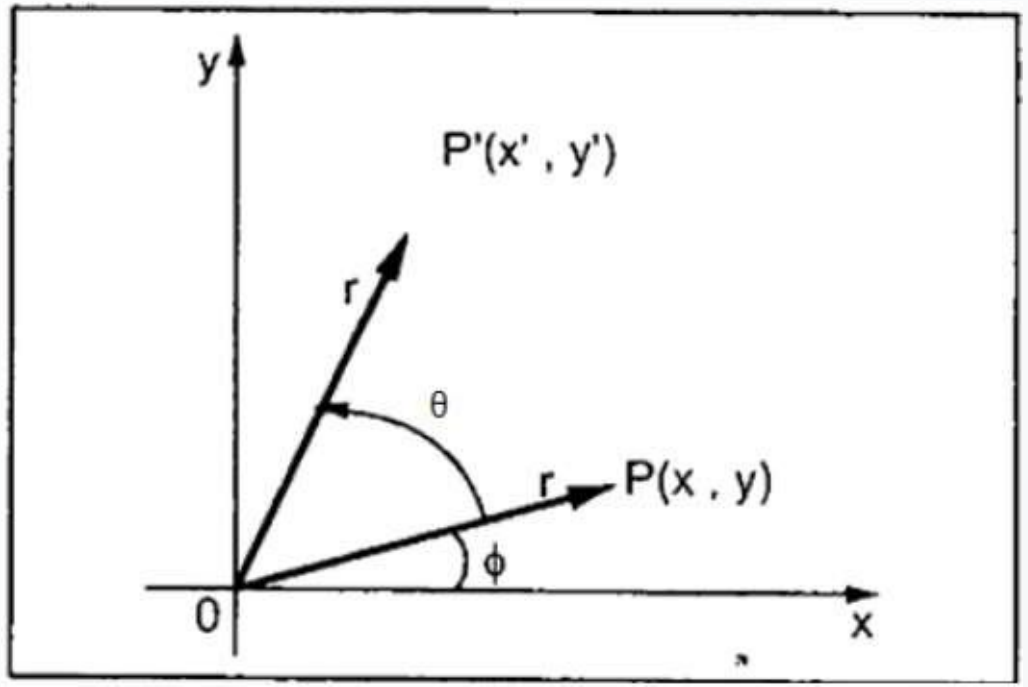
$x'=x\cos\theta-y\sin\theta$

$y'=x\sin\theta+y\cos\theta$

$P' = P \cdot \mathbf{R}$

$$R = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$$

Rotation Matrix

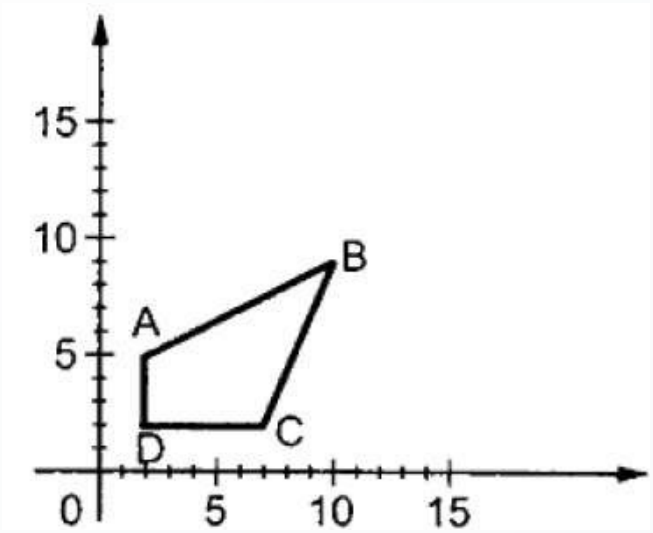


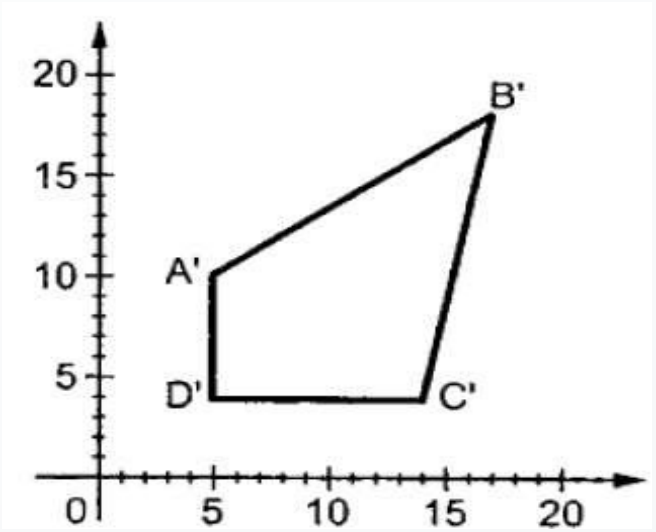
缩放变换 （Scaling）

- Change the size of an object
- Either expand or compress
- Scaling can be achieved by multiplying the original coordinates of the object with the scaling factor to get the desired result
- **$X' = X \cdot S_X$ and $Y' = Y \cdot S_Y$**
- **$P' = P \cdot S$**

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} X \\ Y \end{pmatrix} \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix}$$

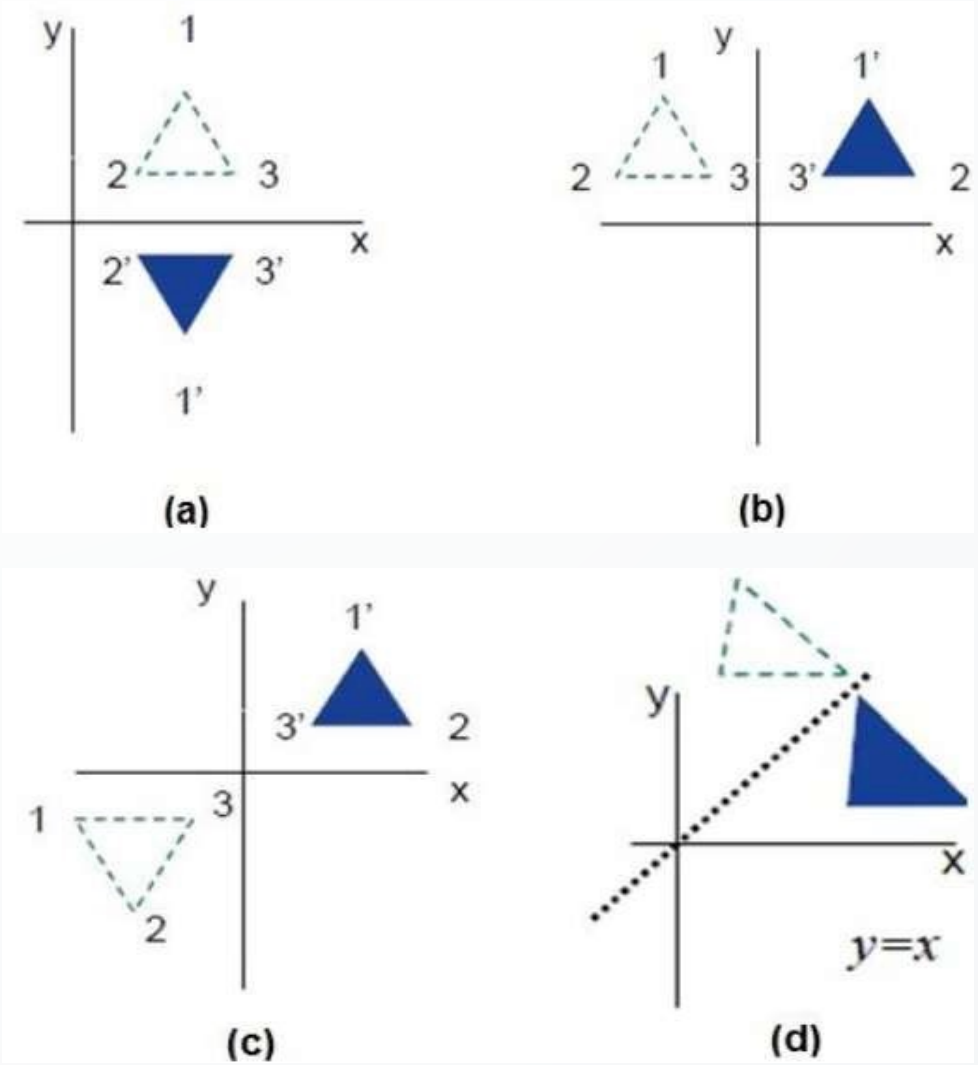
scaling matrix





形状的反射变换 （Reflection）

- 将形状按照某个轴进行镜像变换，可视为按照对称轴翻转180度
- 变换时形状的大小不变



剪切变换 （Sheering）

- 将物体的形状平行倾斜

- X-Shear　　Y-Shear

$$X_{sh} = \begin{bmatrix} 1 & 0 & 0 \\ shx & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

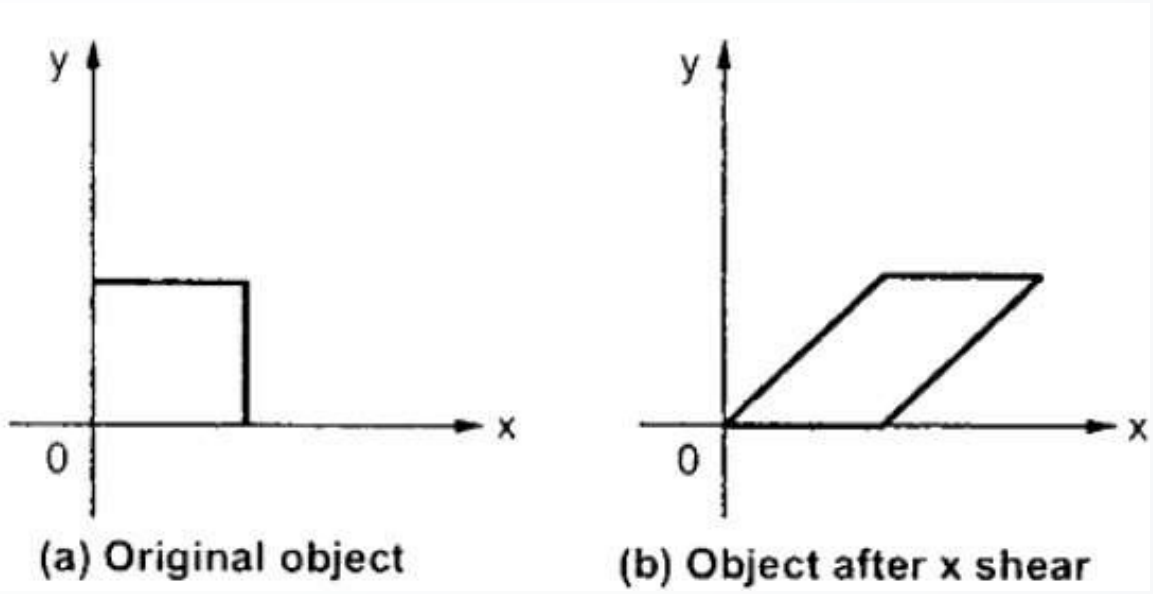
$$X' = X + Sh_x \cdot Y$$

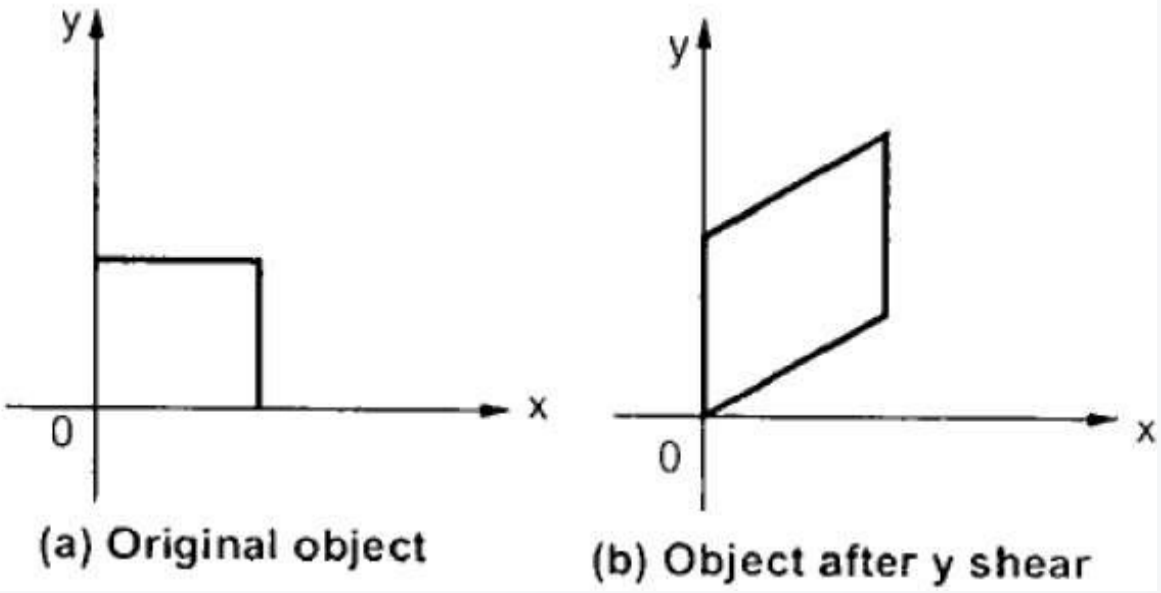
$$Y' = Y$$

$$Y_{sh} \begin{bmatrix} 1 & shy & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$Y' = Y + Sh_y \cdot X$$

$$X' = X$$





组合变化

- 当一个变化 T1 紧跟着另外一个变换 T2，可以通过简单按顺序连乘变换矩阵加以实现，可以被记为： **T = T1•T2**.
- **T · X = X T1 T2 T3 T4 …. Tn**
- **其中，Ti 是** Translation / Scaling Shearing / Rotation / Reflection 中的任意一种变换

动画的实现方式

- 数值的线性插值:

$$X = (Xt - Xs) * \ factor + Xs$$

  - Xs 动画起始状态时的 坐标/尺寸/角度/颜色 等
  - Xt 动画结束状态时的 坐标/尺寸/角度/颜色 等
  - factor $\in [0, 1]$，定义了动画的步速，当 factor = 0 时对应起始状态；当 factor = 1时对应结束状态

- 动画的过程就是控制 factor 从 0 渐变至 1 的过程

动画的实现方式

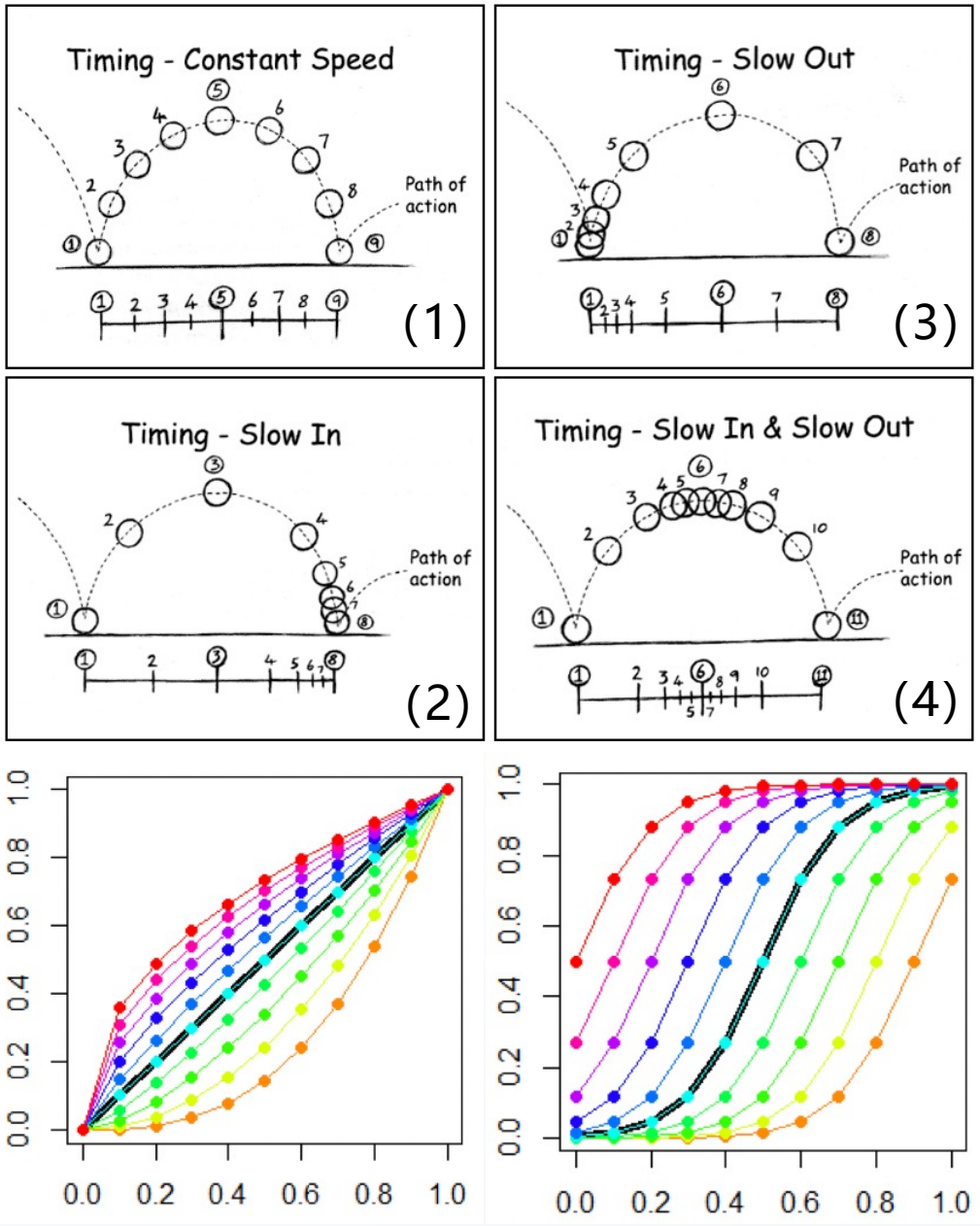
- 步速控制（Pacing）：
  - 匀速：

    $factor = k * (t / duration)$
  - 慢入（Slow In）

    $factor = k * (t / duration)^2$
  - 慢出（Slow Out）

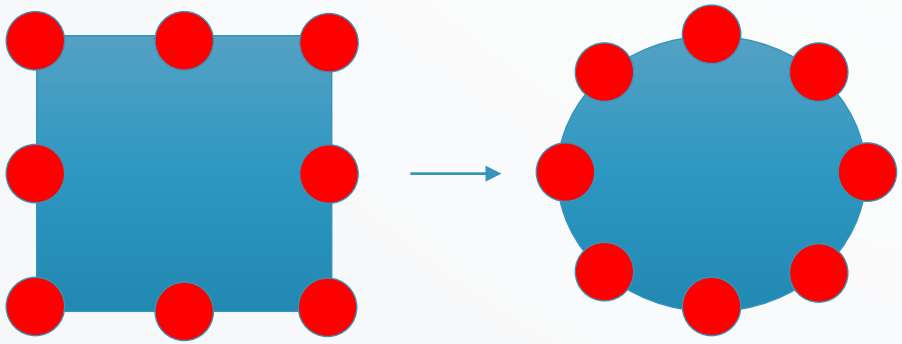
    $factor = k * sqrt(t / duration)$
  - 慢入慢出（Slow In Slow Out）

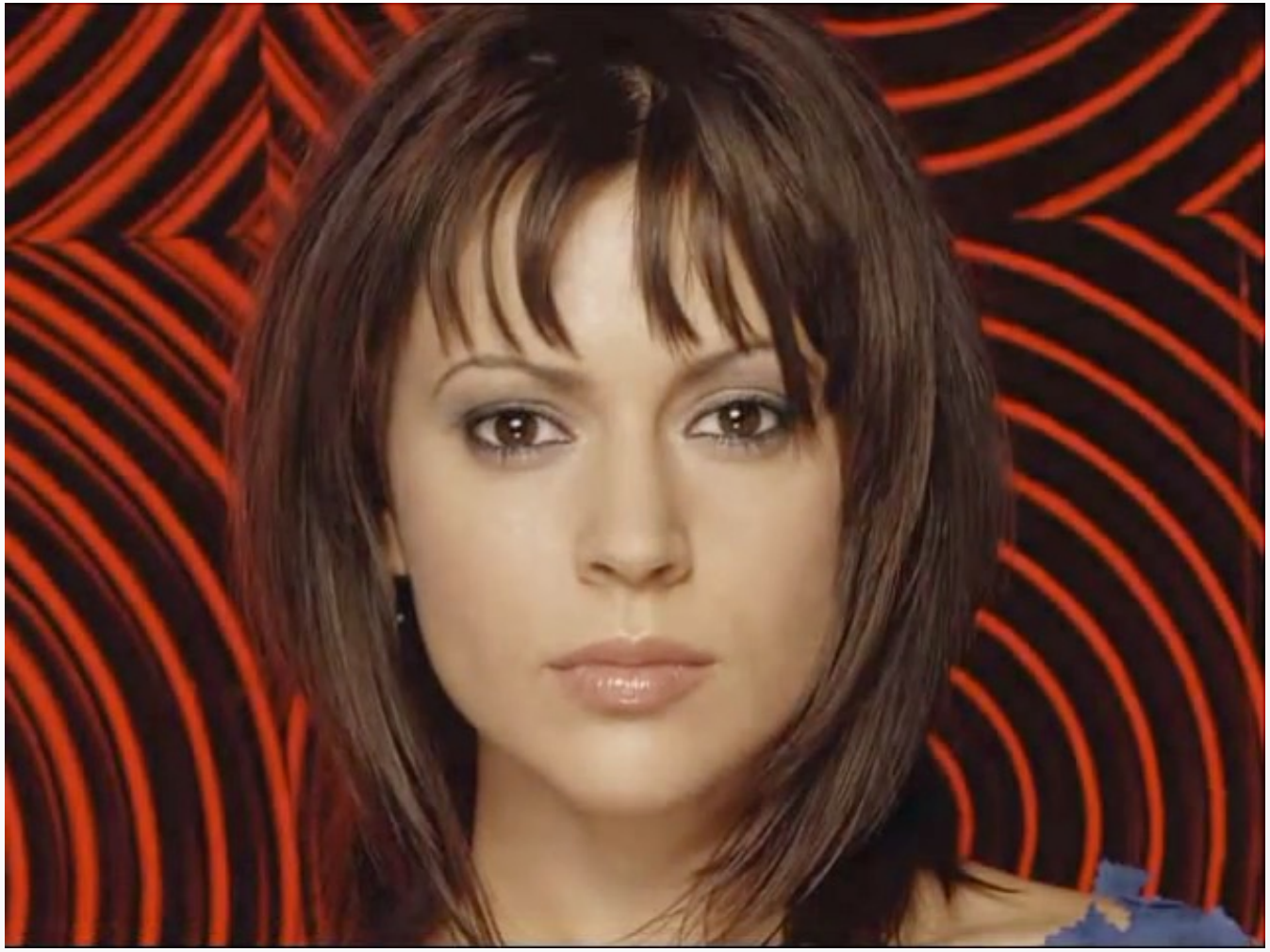
    $factor = 1 + sigmod(t / duration)$



案例4：动画形变（Morphing）

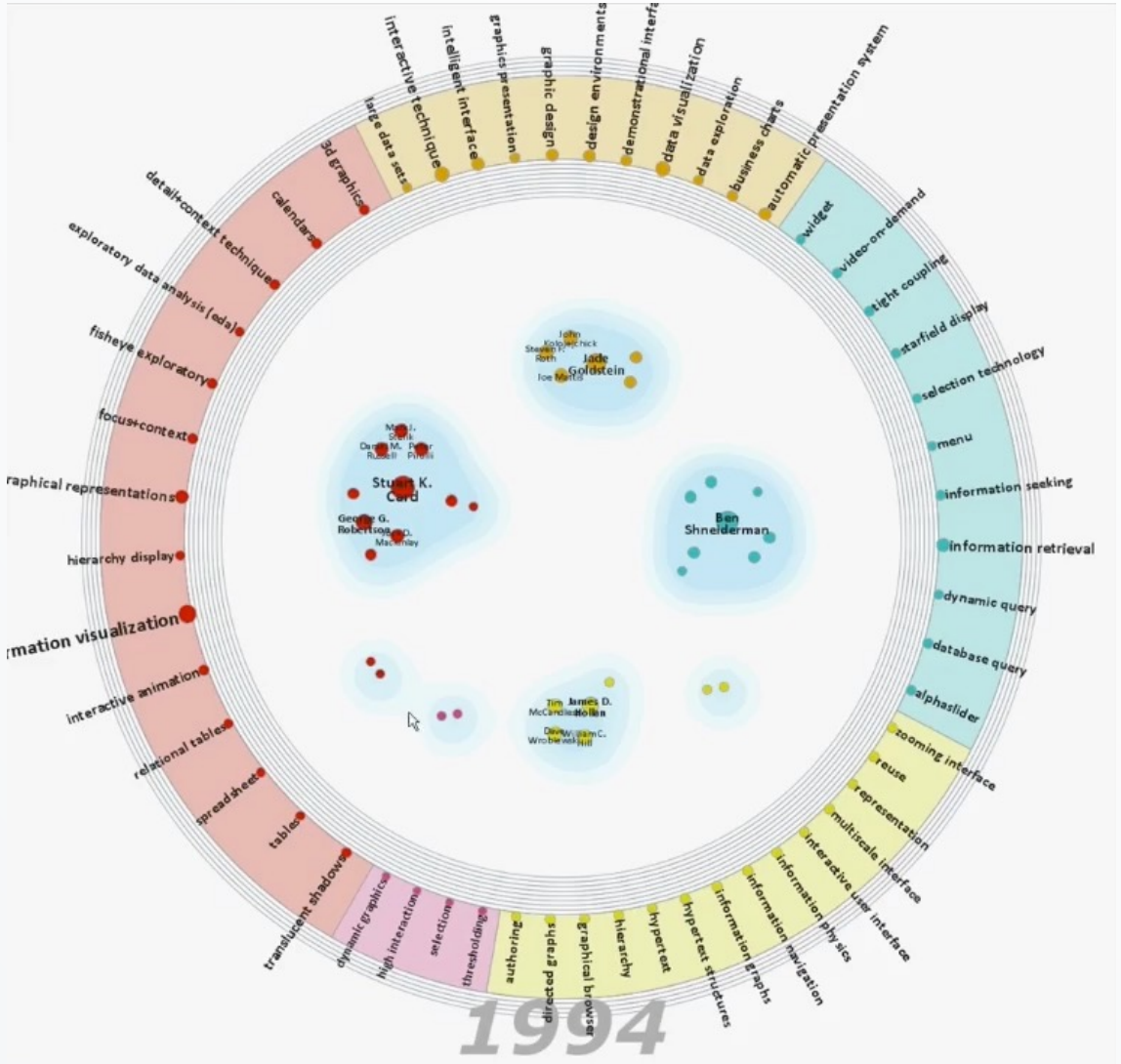
- 从一个形状变换到另一个形状
- 对形状进行采样，并对擦痒点进行匹配，变换





案例5： Translation & Scaling

案例6： Translation & Rotation



每个点代表一个学者

学制之间通过他们的合作关系连接

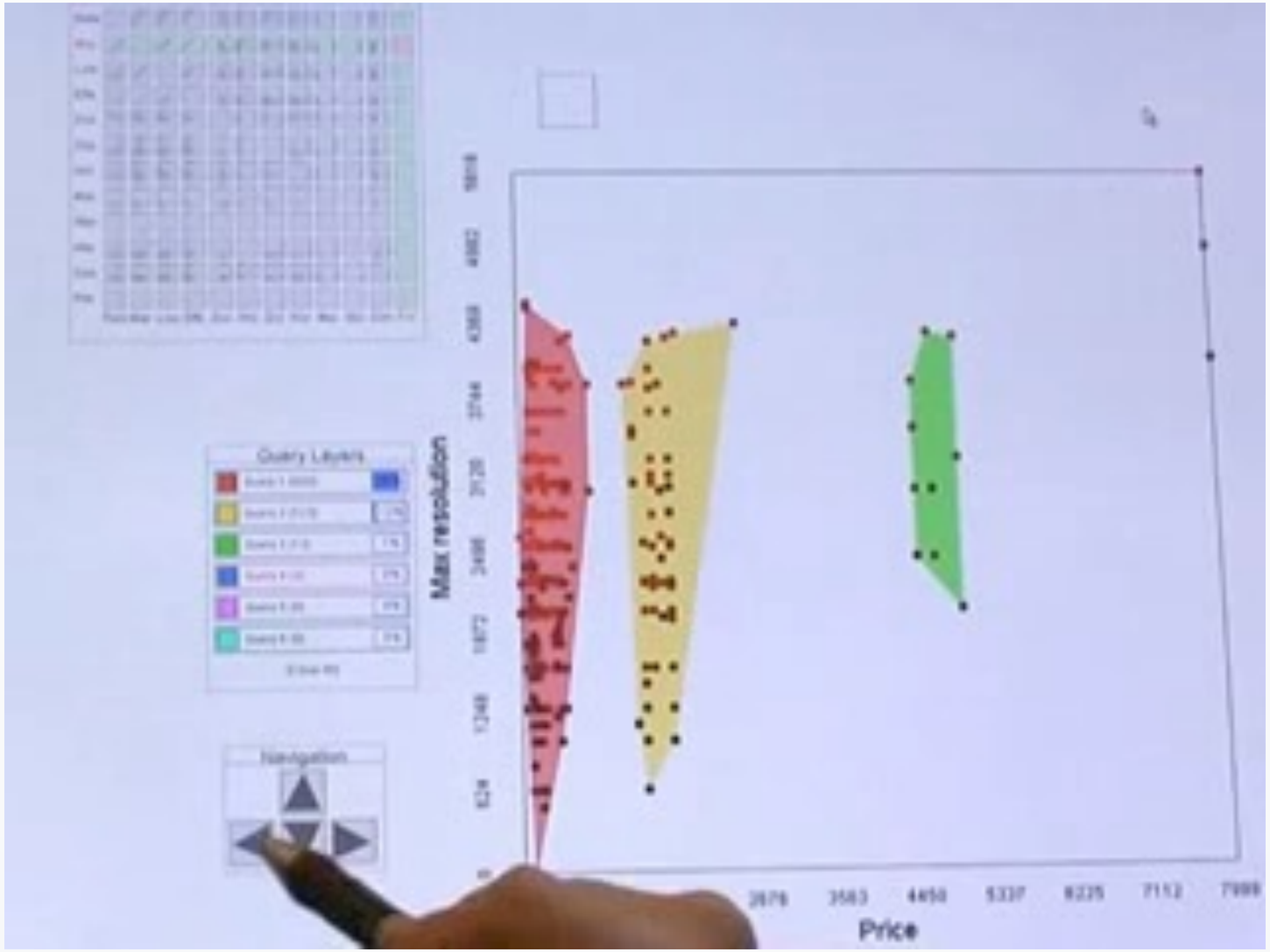
四周的短语表示研究课题关键词

学者与关键词之间的连线代表学者从事相关的研究工作

不同的圆环代表不同的年份，点击切换圆环可以显示不同时间的情况

案例7: 用动画展现弯曲的物体表面

案例8: 用动画在不同可视化试图之间切换



课程总结

- 本节课
  - 交互
    - 常见交互类型
    - 交互范式1：概览+细节
    - 交互范式2：焦点+上下文
  - 动画
    - 可视化中的动画
    - 动画的设计原则
    - 动画的实现方式
- 下节课
  - 面向不同数据的可视化

第四讲：交互技术与动画

信息可视化

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