

# Visualisation d'informations (3)

## Représentations des données multivariées

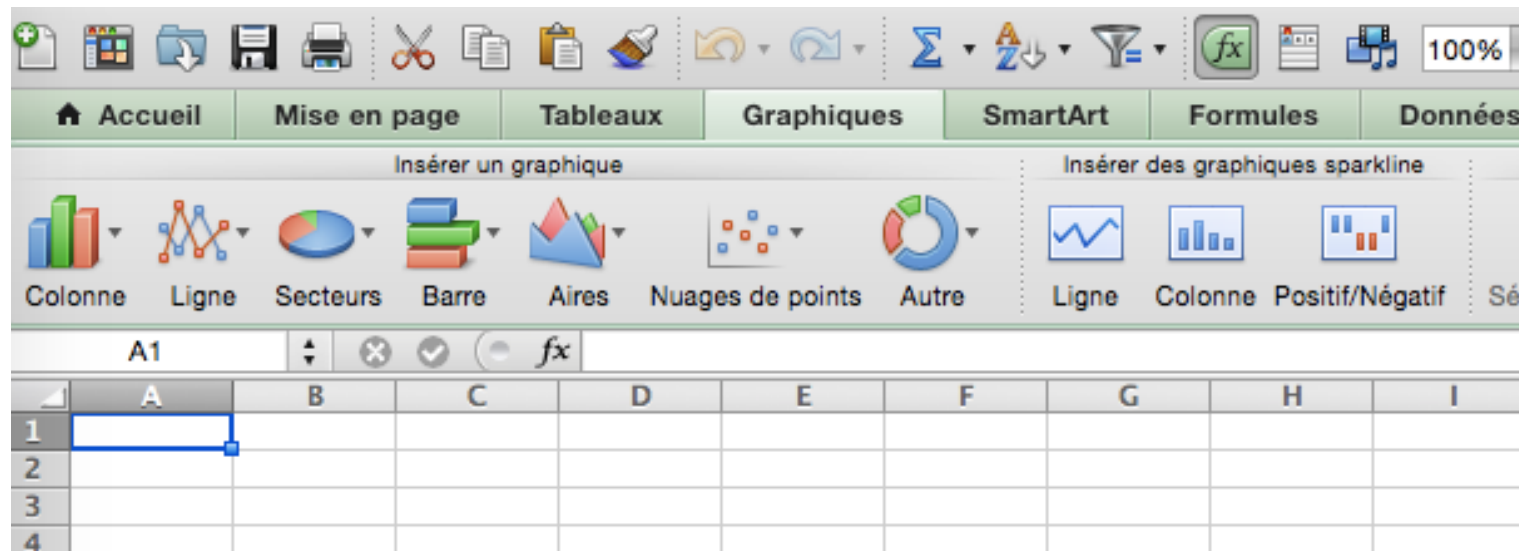
Pierre Cubaud <cubaud@cnam.fr>

Jan. 2021

Données multivariées :  $\geq 3$  facteurs

Exemple : automobile = (prix, places, consommation, vitesse ...)

Si 1 ou 2 facteurs : utiliser un tableur+grapheur



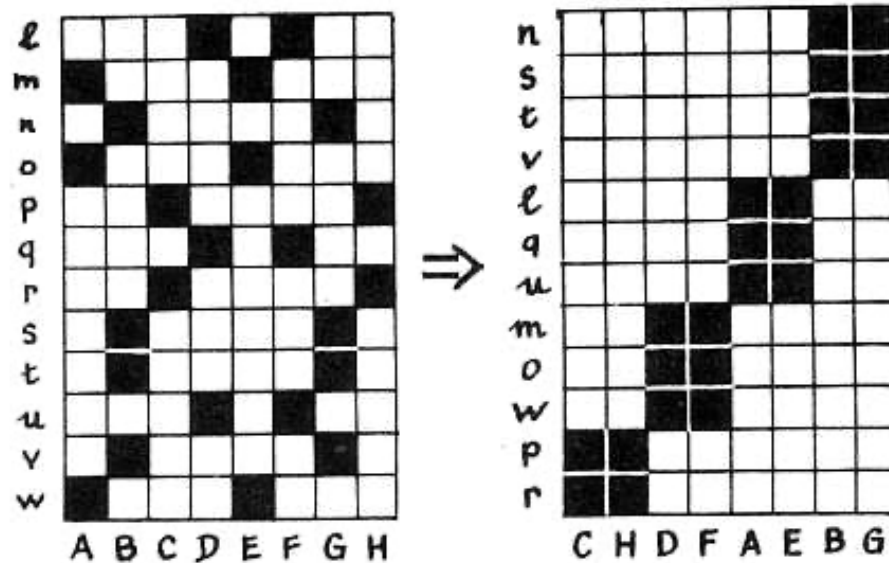
Je mets les graphes dans cette catégorie

## Plan de l'exposé

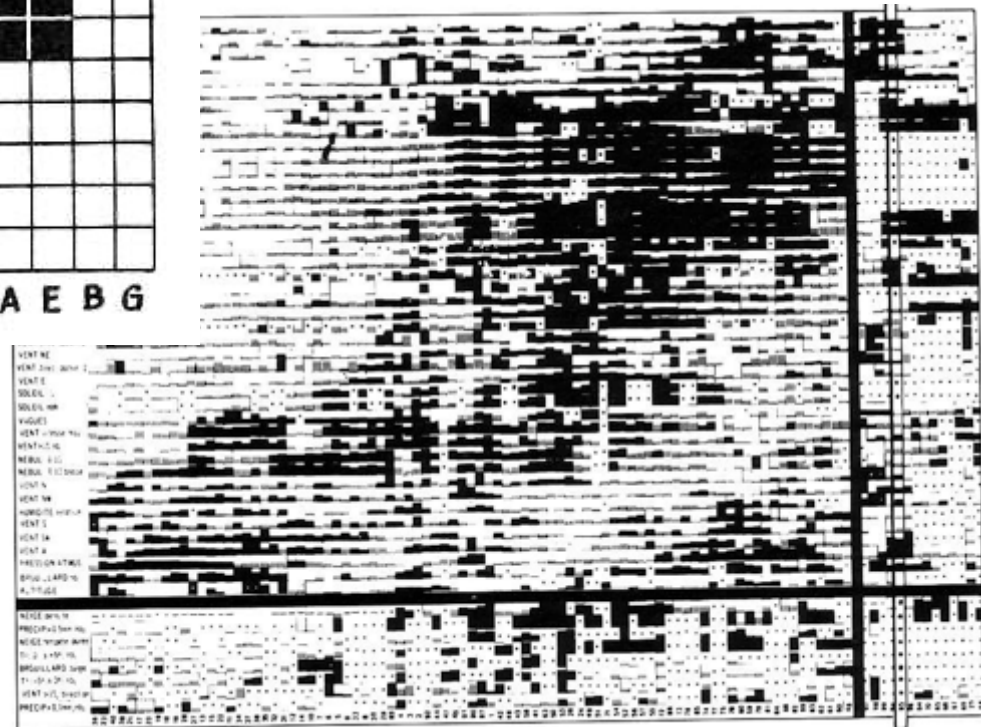
1. Représentation des tables
2. Petits multiples
3. Généralités sur les graphes
4. Représentations des arbres
5. Représentation des graphes généraux

## 1. Représentation des tables

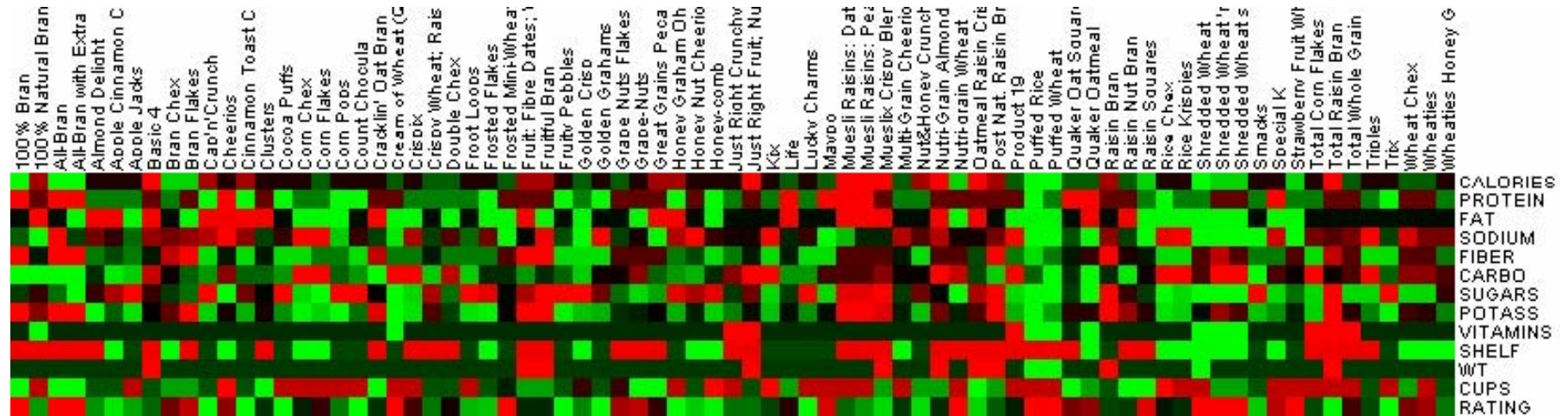
## Matrices ordonnables (Bertin, 70' )



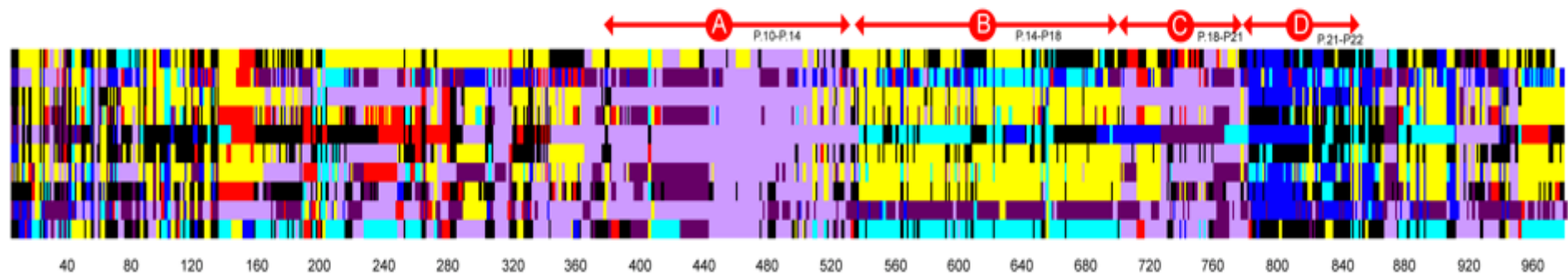
(cf cours #1)



## Exemples :

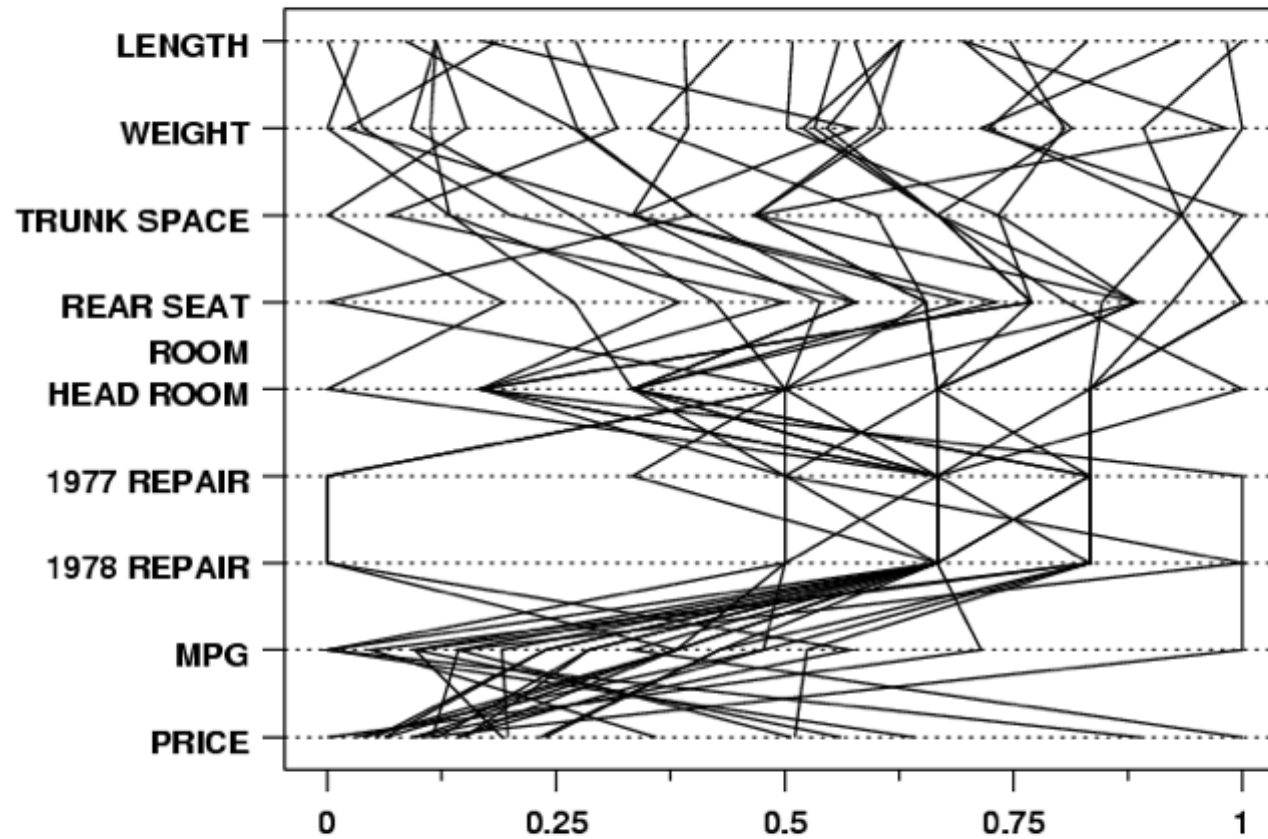


<http://hcil.cs.umd.edu/trs/2005-20/2005-20.html>



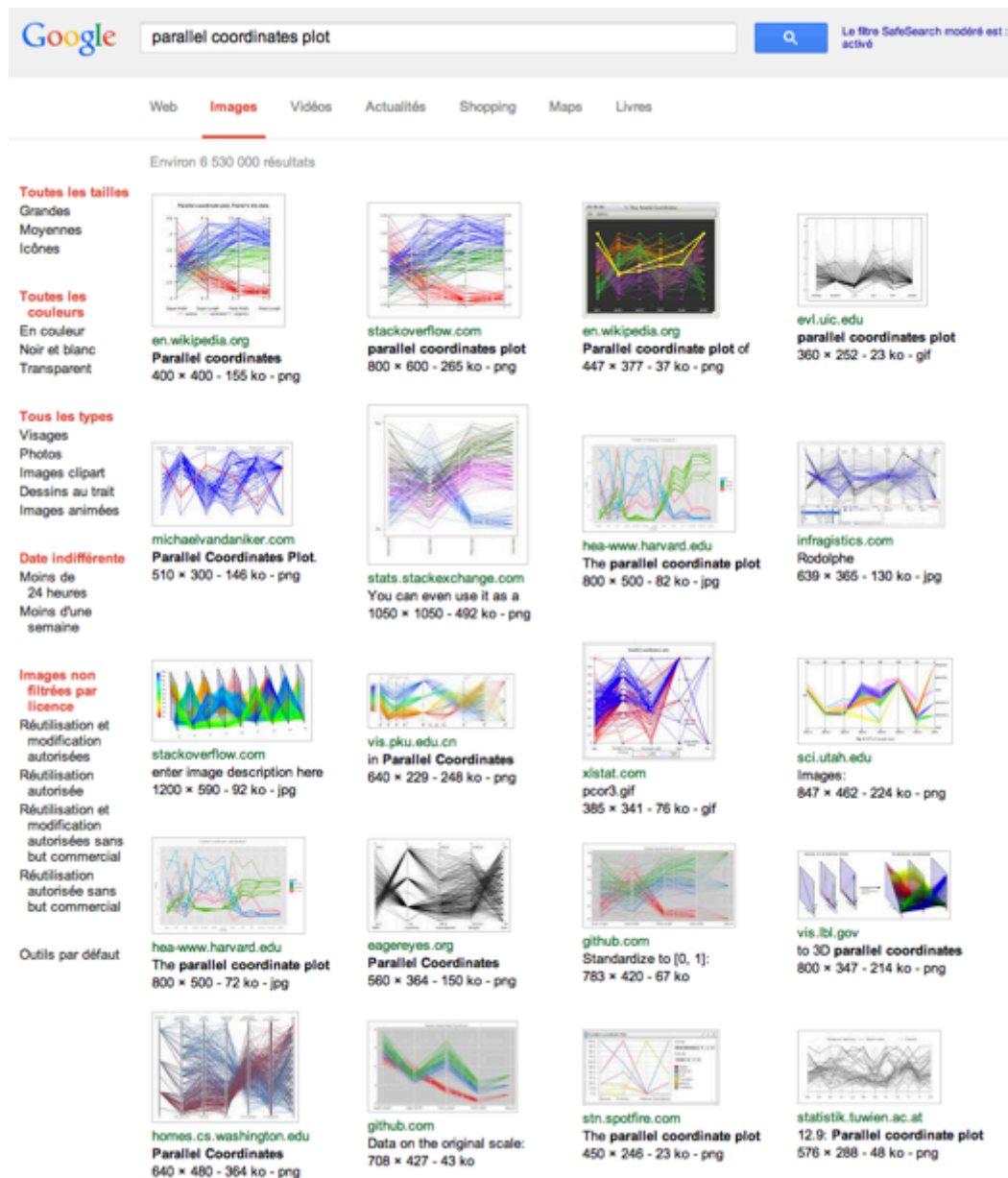
Hsu & Cubaud, HCI' 2009

## Parallel coordinate plot



A. Inselberg, 1959

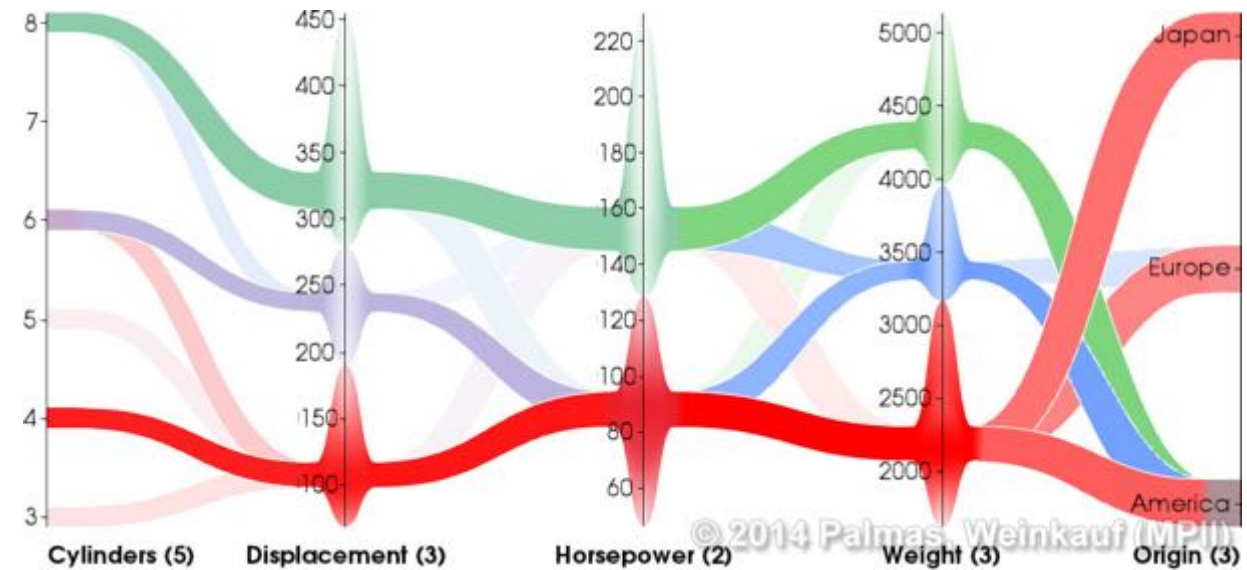
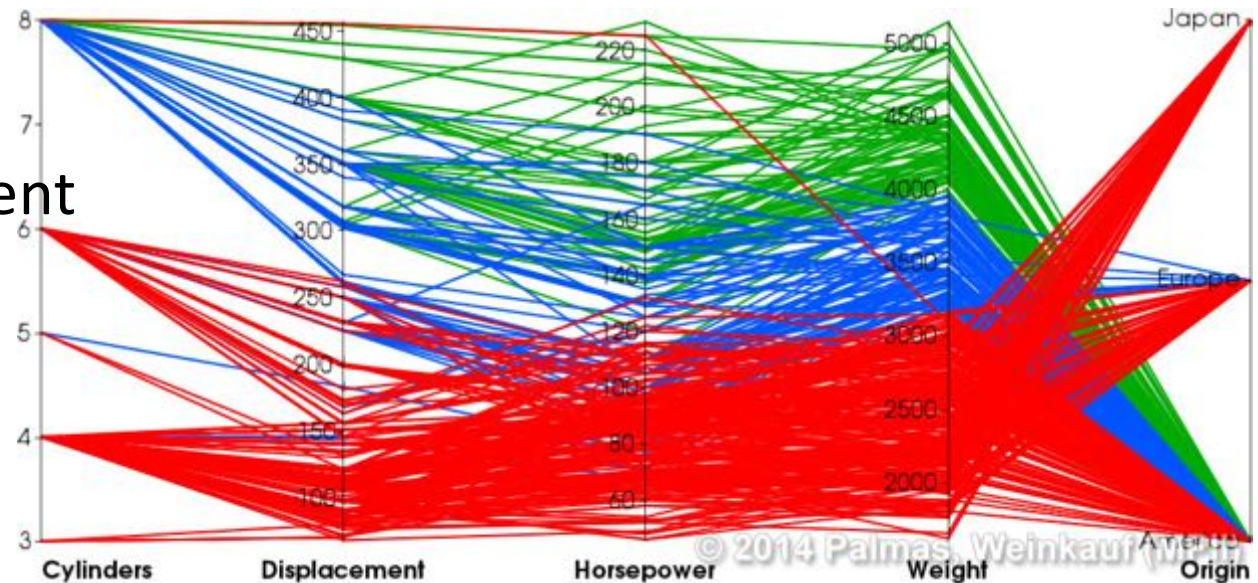
# Nombreuses variantes de rendu



recherche d'images  
dans Google  
sur le terme

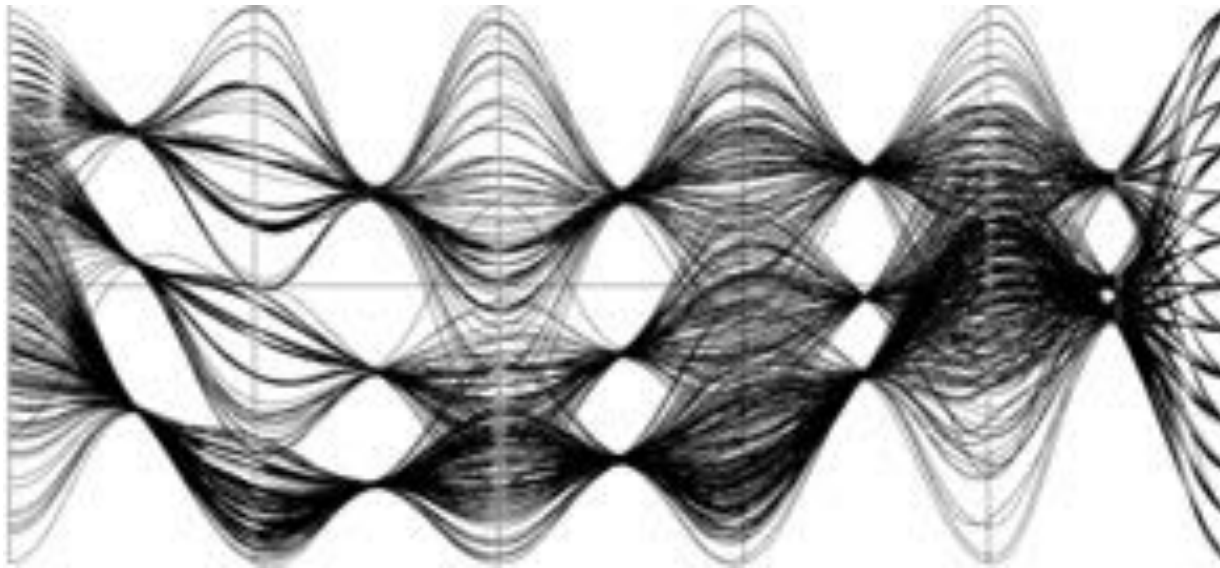
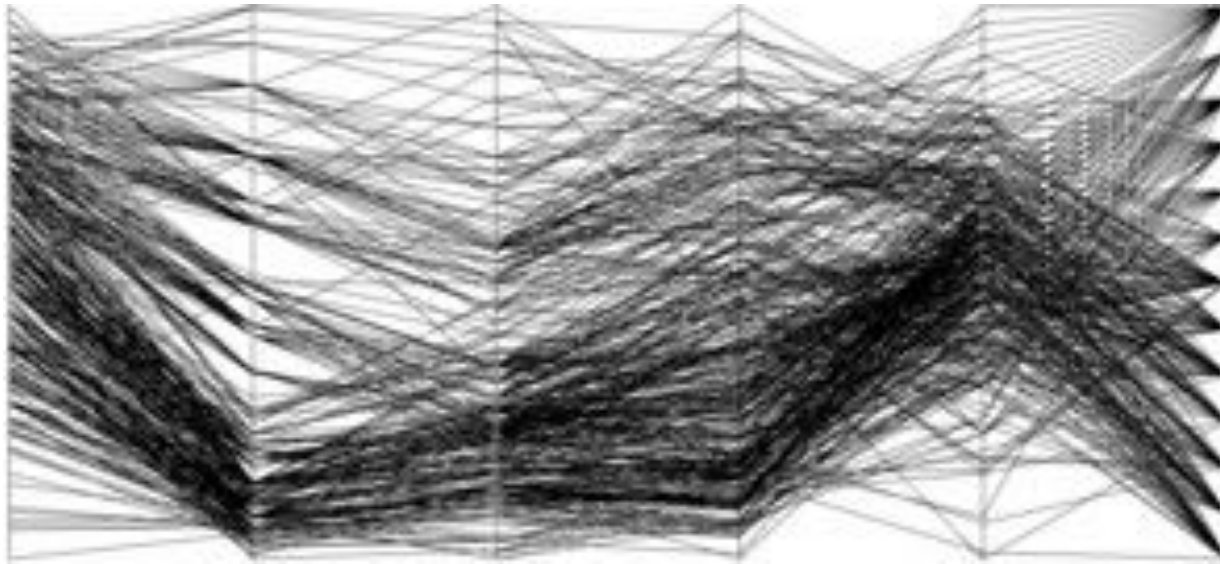
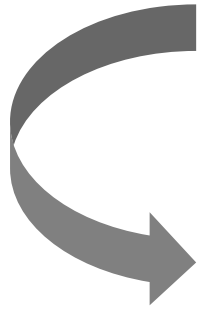


En particulier :  
question du groupement  
(bundling)



<http://www.csc.kth.se/~weinkauff/>



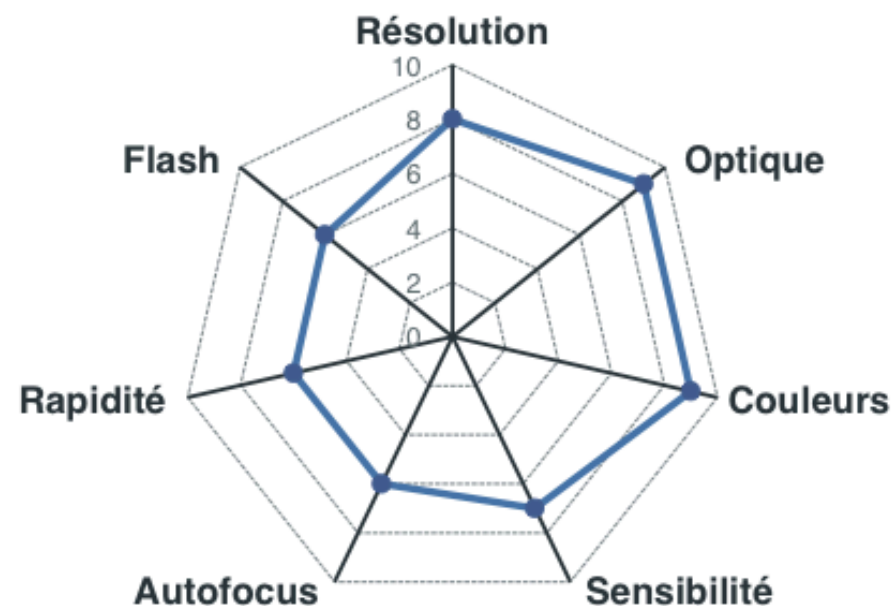


<https://www.vis.uni-stuttgart.de/forschung/infovis-visualanalytics/parallel-coordinates.html>

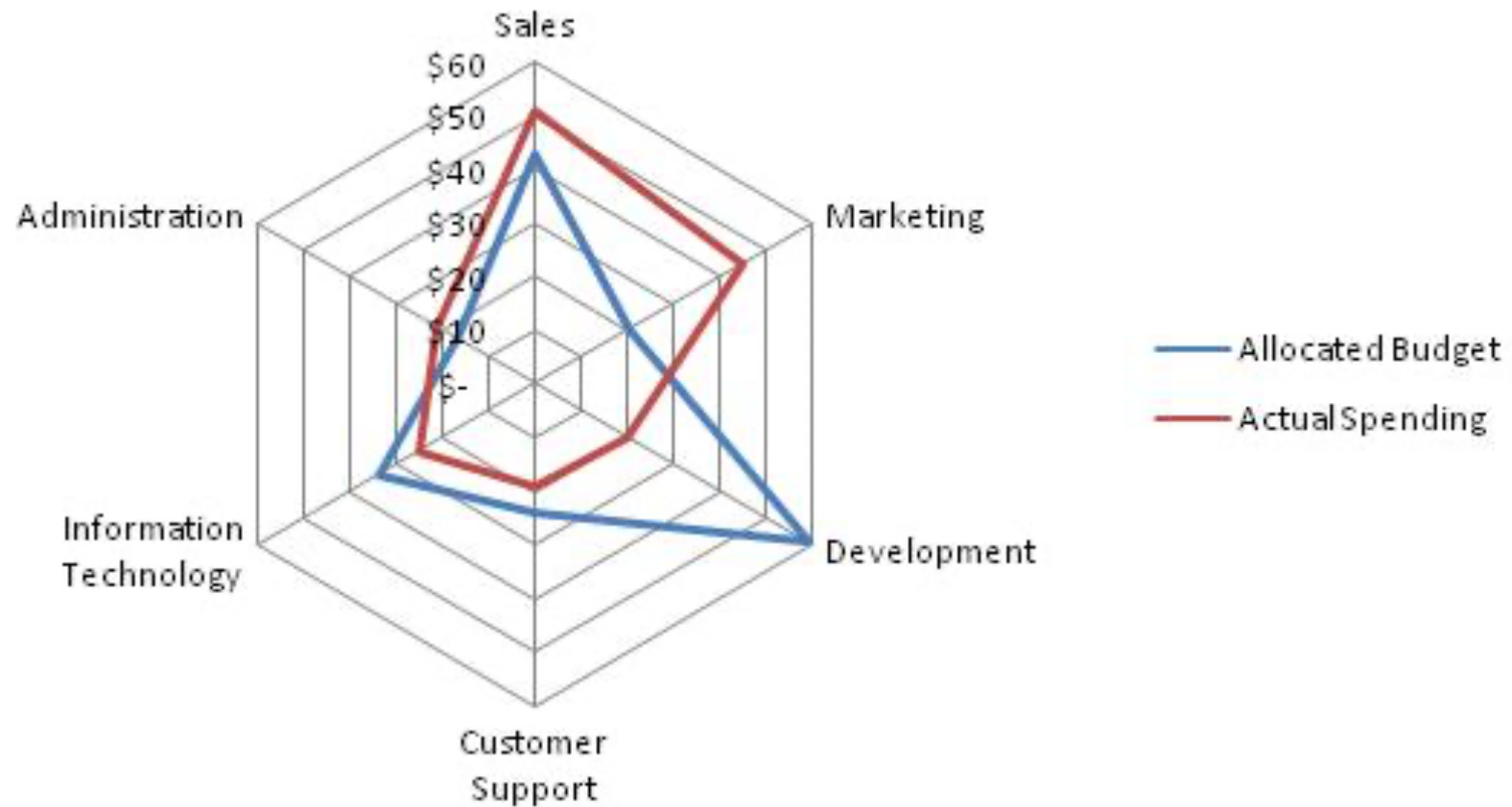
## Diagramme en étoile (ou : star plot, radar, diagramme de Kiviat ...)



Le Samsung WB35F est abordable est doté d'un capteur au format 1/2.3" (6,7 mm) et d'un écran de 2,7" (6,7 cm) affichant une définition initiale du capteur est de 15,9 millions de pixels. Il a obtenu de bons résultats aux tests optiques, un grand-angle de 24 mm et d'un zoom optique. Le mode macro permettant une mise au point à très courte distance. Le Samsung WB35F a décroché des notes correctes en matière de sensibilité et une excellente note de rapidité. Son autofocus manque un peu de réactivité. Globalement, la vitesse n'est pas son point fort. Le Samsung WB35F communique et intègre Wi-Fi et NFC pour partager ses photos et vidéos directement ou au travers d'un réseau local. Il peut filmer des vidéos en 720p à 30 images/s.



en superposition :



[http://upload.wikimedia.org/wikipedia/commons/1/18/Spider\\_Chart2.jpg](http://upload.wikimedia.org/wikipedia/commons/1/18/Spider_Chart2.jpg)

## 2. Petits multiples



[Tufte – Envisioning ...]

## Conclusion

Well-designed small multiples are

- inevitably comparative
- deftly multivariate
- shrunken, high-density graphics
- usually based on a large data matrix
- drawn almost entirely with data-ink
- efficient in interpretation
- often narrative in content, showing shifts in the relationship between variables as the index variable changes (thereby revealing interaction or multiplicative effects).

[Tufte – Envisioning ...]

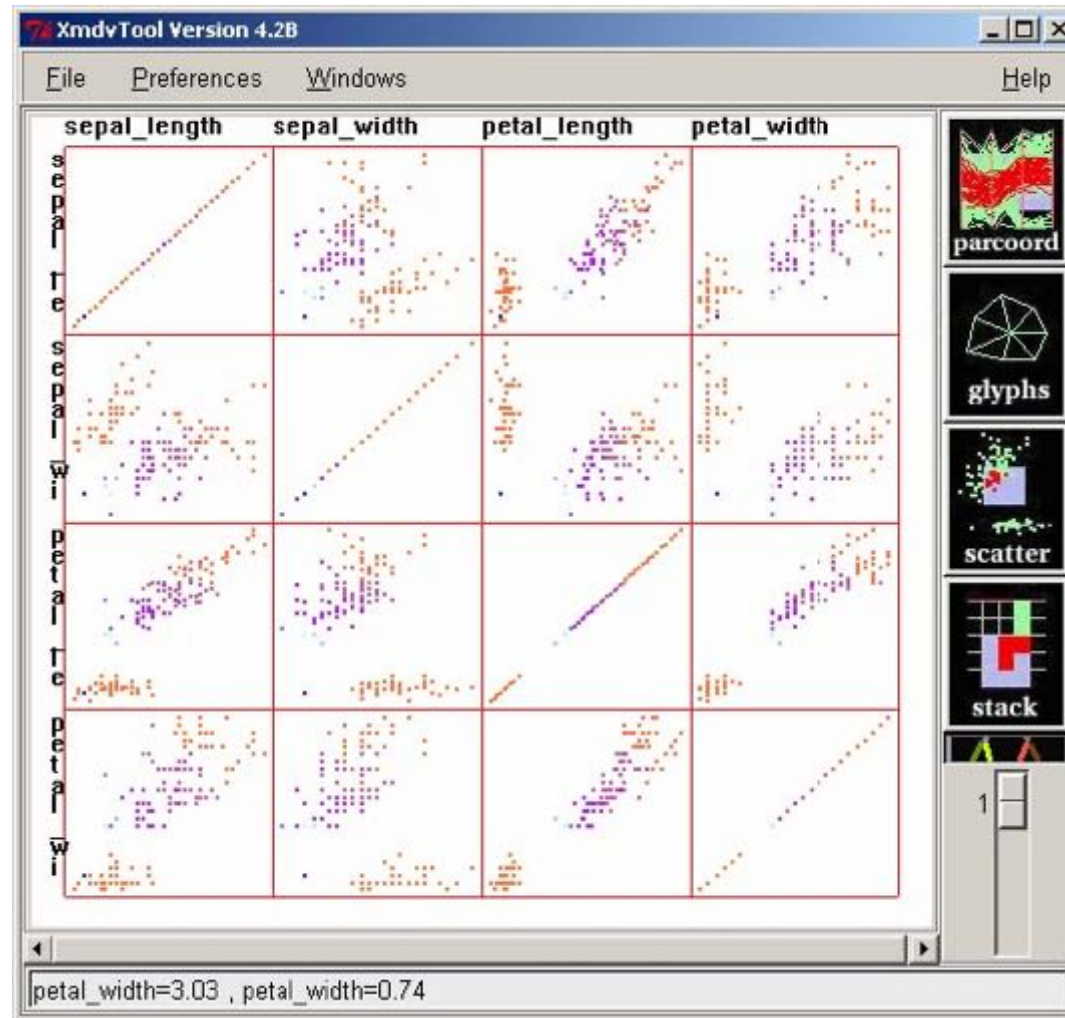
Small multiples reflect much of the theory of data graphics:

For non-data-ink, less is more.

For data-ink, less is a bore.<sup>6</sup>

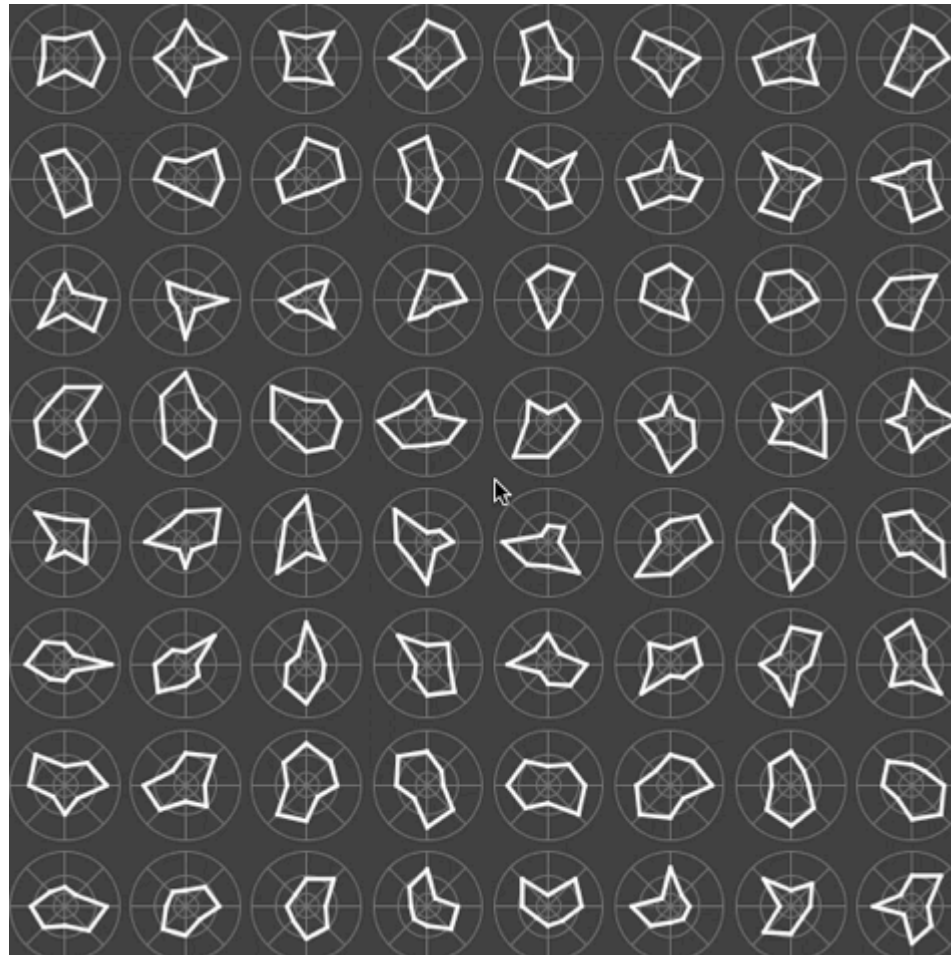
<sup>6</sup>The two aphorisms on the meaning of “less” are, respectively, credited to Ludwig Mies van der Rohe and to Robert Venturi, *Complexity and Contradiction in Architecture* (New York, second edition, 1977), p. 17.

## PM avec les nuages de points





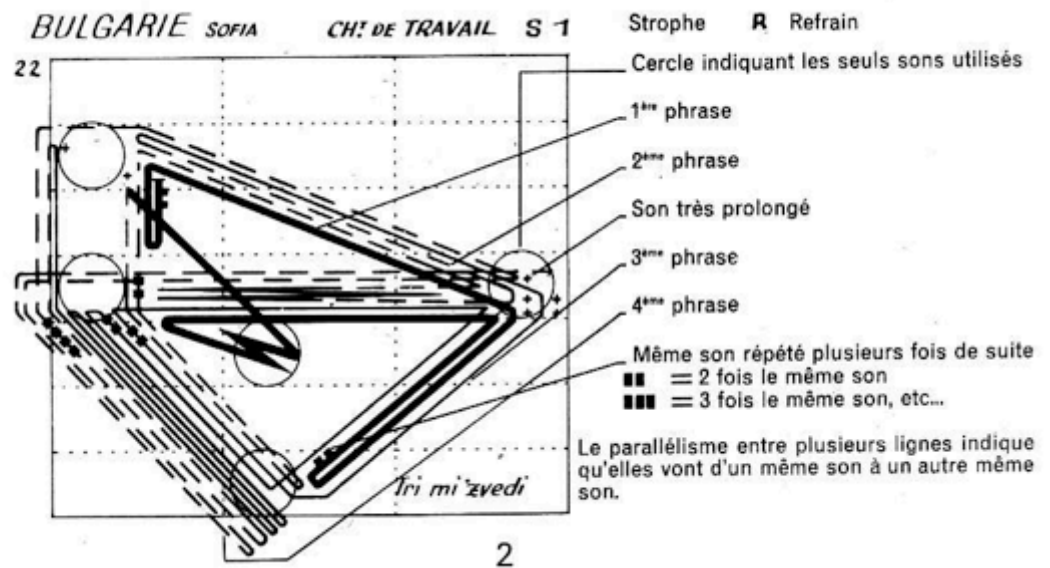
## PM avec les radars



## Exemple dans [Bertin]

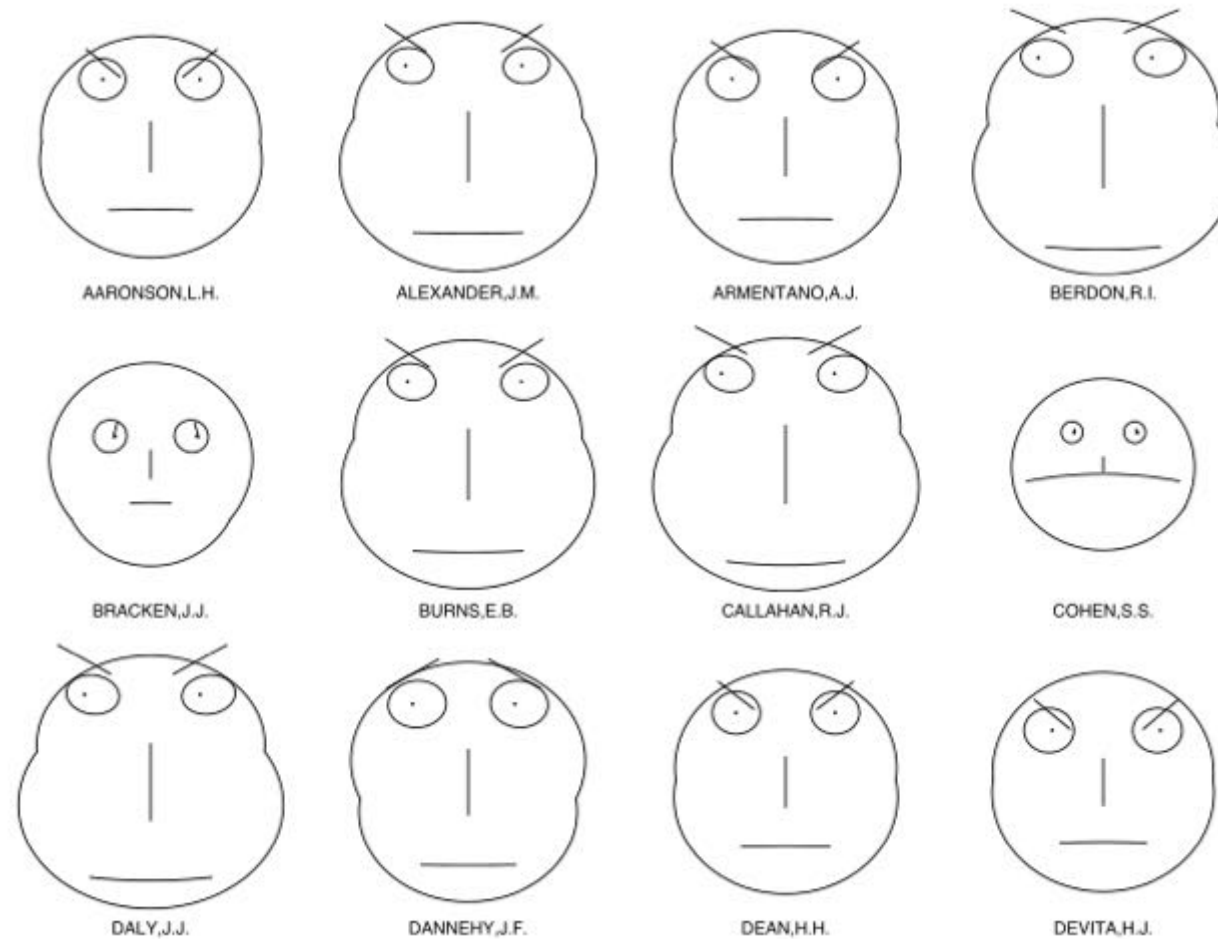
	<i>N.</i> Non-arrondies	ANTÉRIEURES . CENTRALES . POSTÉRIEURES .					
	<i>A.</i> Arrondies	<i>N.</i>	<i>A.</i>	<i>N.</i>	<i>A.</i>	<i>N.</i>	<i>A.</i>
Hautes		ɪ	ʊ	ɛ	ʊ	ɛ	u
Mi-hautes		ɪ	ʊ	ɛ	ʊ	ɛ	u
Médianes hautes		e	ö	ɛ	o	ɛ	o
Médianes		ɛ	ñ	ə	ñ	ɛ	ɲ
Médianes basses		ɛ	ɔ	ɛ	ɔ	ɛ	ɔ
Mi-basses		æ	ɔ	æ	ɔ	æ	ɔ
Basses		æ	ö	a	ɔ	a	ɔ

1





## au passage : les visages de H. Chernoff (1973)



[http://en.wikipedia.org/wiki/Chernoff\\_face](http://en.wikipedia.org/wiki/Chernoff_face)

### 3. Les graphes

cf cours  
sur la fouille  
de graphe

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#### Définitions

Un graphe est défini par un couple  $G = (V, E)$  tel que :

- $V$  (pour l'anglais *vertices*) est un ensemble fini de sommets
- $E$  (pour l'anglais *edges*) est un ensemble fini de arêtes

Un graphe peut être orienté, ou non :

- si oui, les couples  $(v_i, v_j) \in E$  sont ordonnés,  $v_i$  est le sommet initial,  $v_j$  est le sommet terminal.
- on appelle alors le couple  $(v_i, v_j)$  un *arc*, représenté par  $\vec{v_i v_j}$
- si non, les couples ne sont pas orientés et  $(v_i, v_j)$  est dit *non ordonné*, on l'appelle *arête*, représenté par  $v_i - v_j$

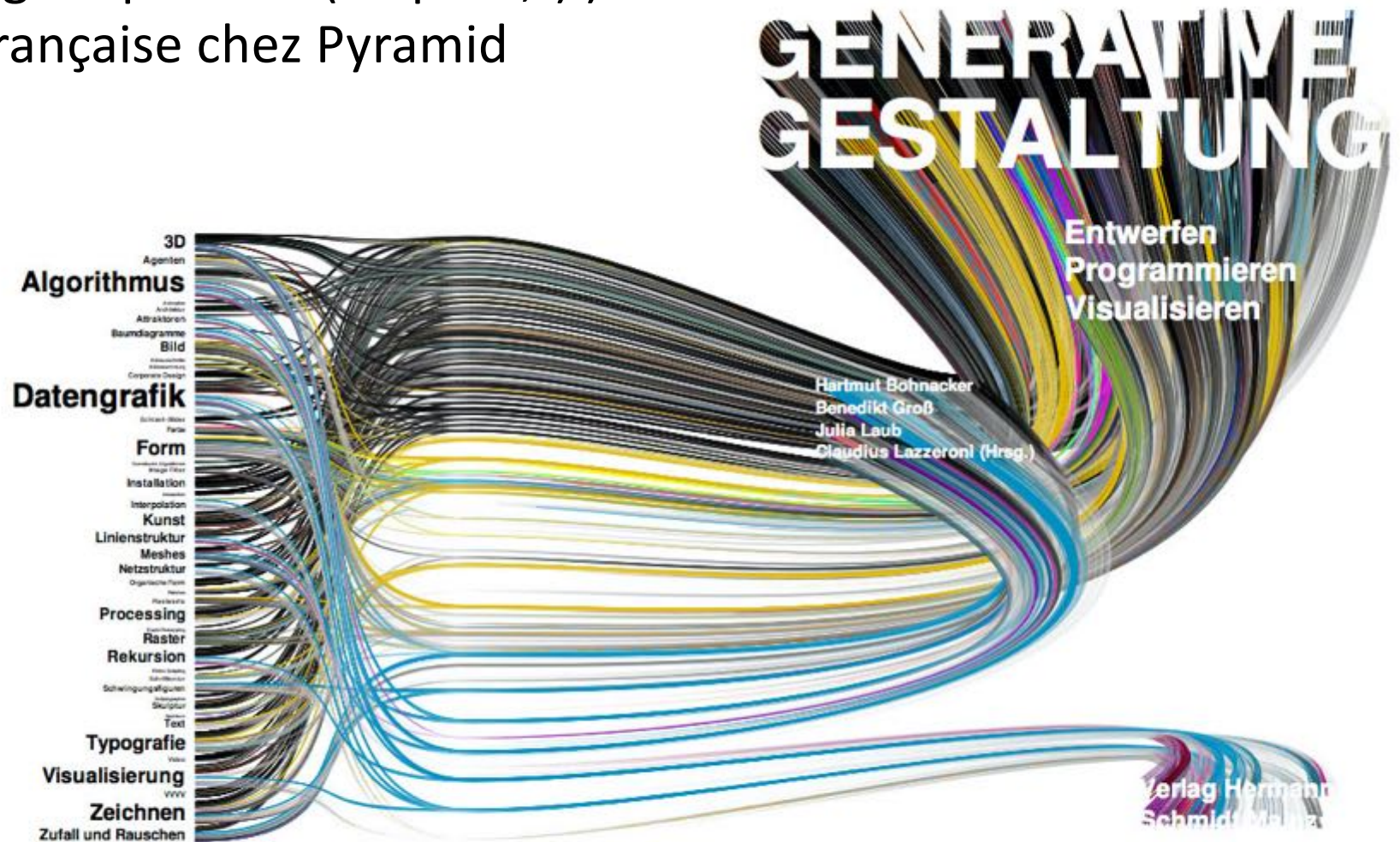
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#### Terminologie

- l'**ordre** d'un graphe, c'est son nombre de sommets (souvent désigné par  $n$ ).
- une **boucle** est un arc/une arête reliant un sommet à lui-même
- un graphe dépourvu de boucle est dit **élémentaire**
- un graphe **simple** ne comporte pas de boucle et au plus une arête entre deux sommets
- un graphe **partiel** est le graphe obtenu en supprimant certains arcs ou arêtes
- un **sous-graphe** est le graphe obtenu en supprimant certains sommets et tous les arcs/arêtes incidents aux sommets supprimés.
- un graphe est dit **complet** s'il comporte une arête  $(v_i, v_j)$  pour toute paire de sommets  $(v_i, v_j) \in E^2$ .
- un sommet  $v_i$  est dit **adjacent** (familièrement on parle de **voisins**) à un autre s'il existe une arête entre eux.
- le **degré** d'un sommet est le nombre de d'arêtes incidentes à ce sommet.

le cnam

Un magnifique livre (de plus ;-))  
trad. française chez Pyramid

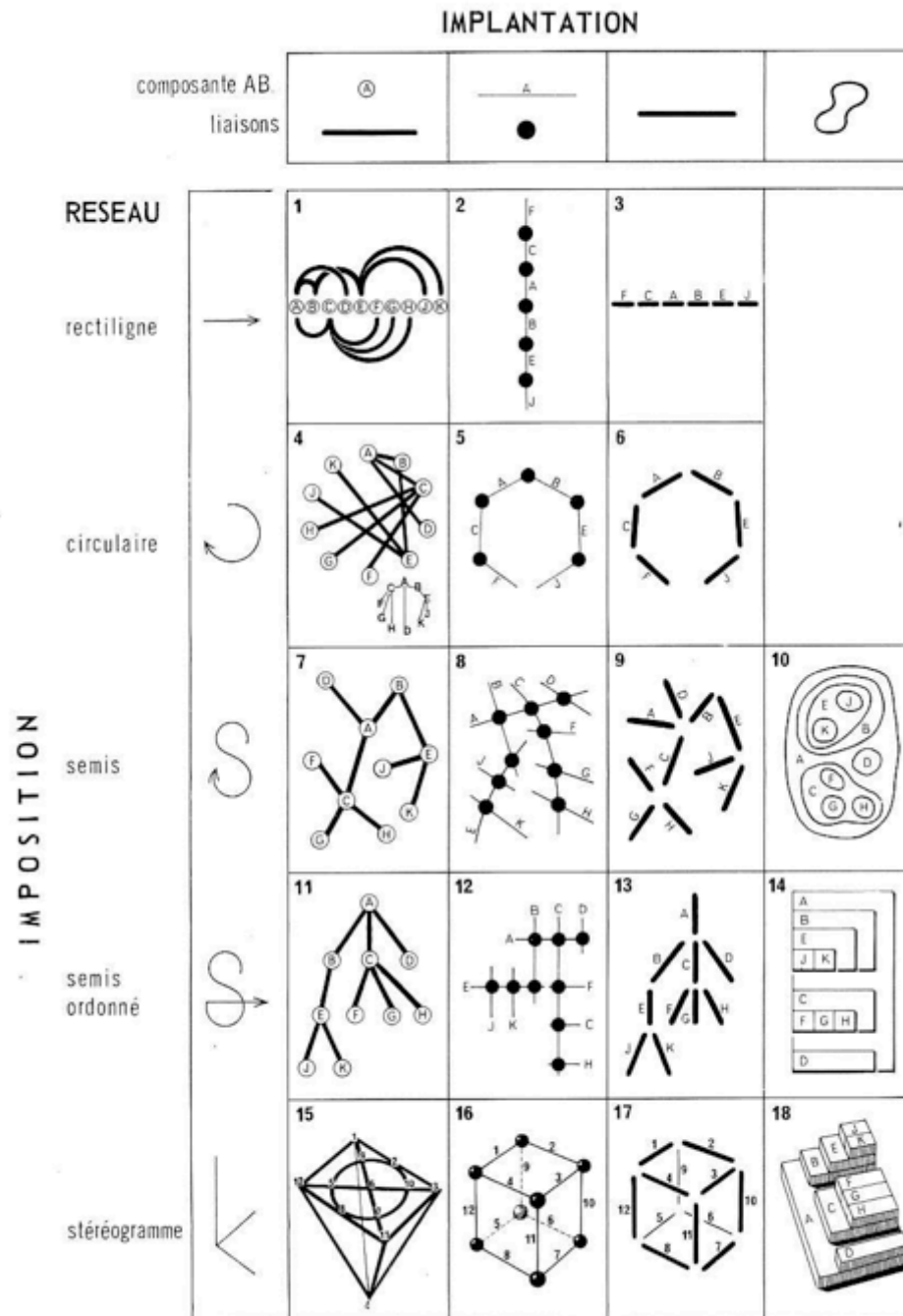


tous les codes du livre : <http://www.art-generatif.com/>



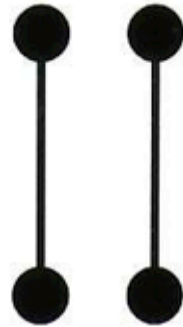
# Représentation des graphes

[Bertin2]

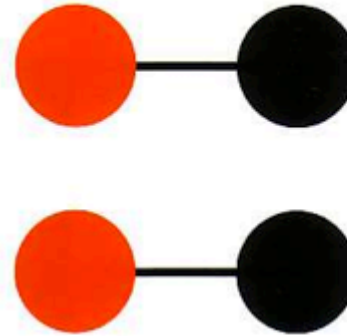


# Les relations

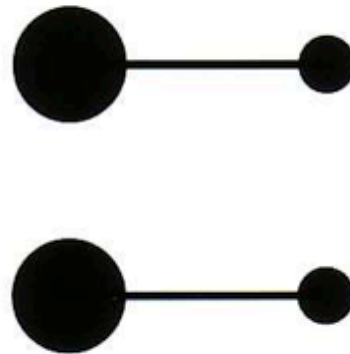
a



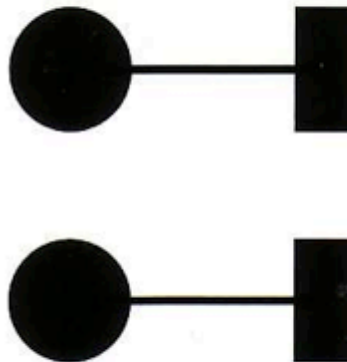
b



c

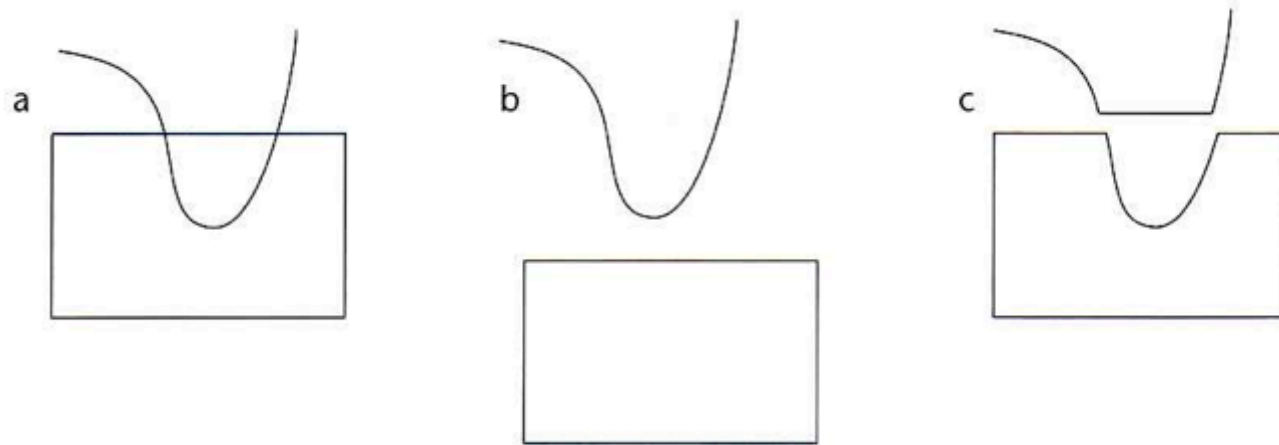


d

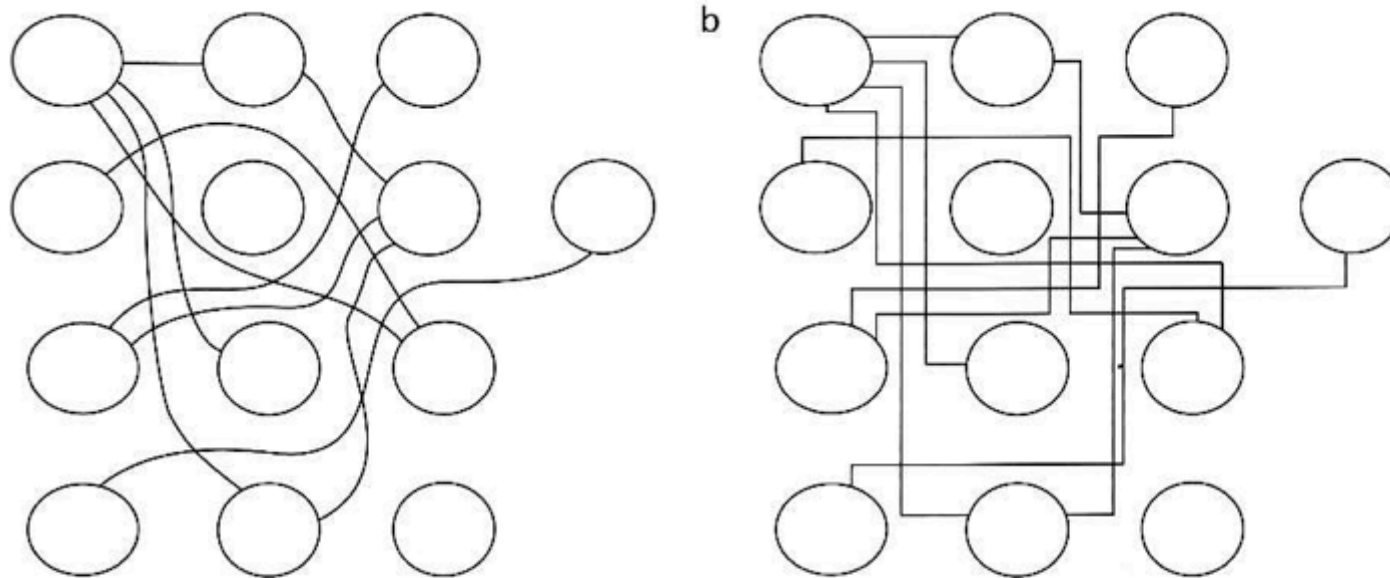


Connectedness is a powerful grouping principle that is stronger than (a) proximity, (b) color, (c) size, or (d) shape.

[Ware]



The pattern on the left (a) is perceived as a curved line overlapping a rectangle (b) rather than as the more angular components shown in (c).



[Ware]

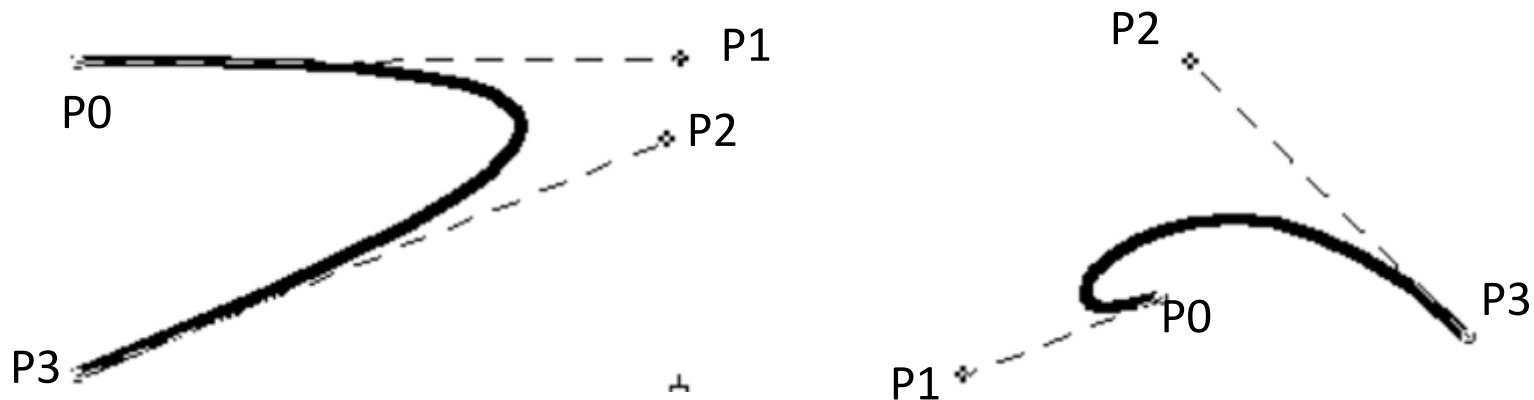
In (a), smooth continuous contours are used to connect the elements, whereas in (b), lines with abrupt changes in direction are used. It is much easier to perceive connections when contours connect smoothly.

Remarque sur les arcs non rectilignes :

utilisation des courbes paramétrées (Bézier, Splines)

$$f(u) = \sum_{i=0}^3 B_i(u) \vec{P}_i \quad \text{polynôme de degré 3}$$

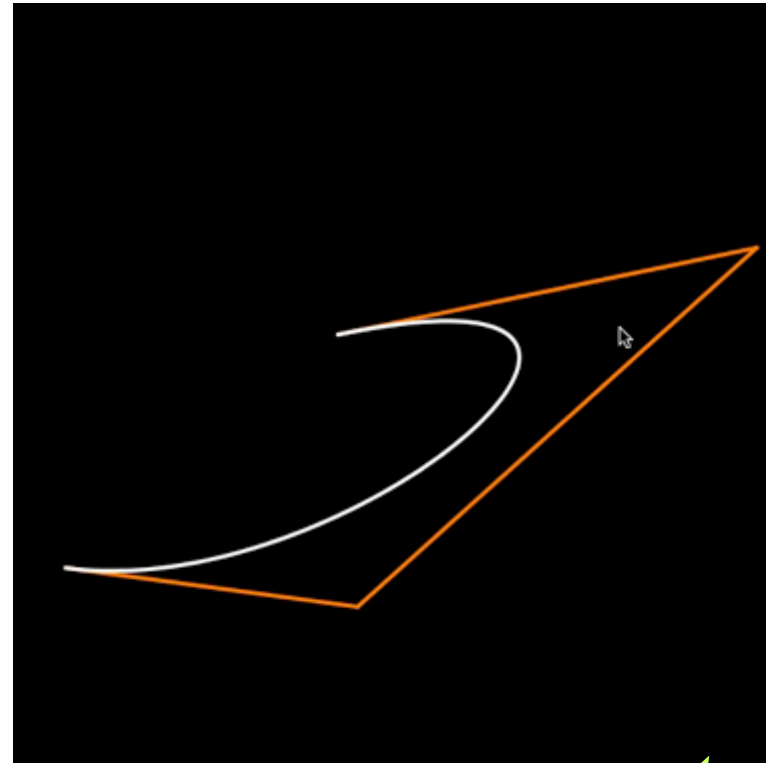
$$= \vec{P}_0(1-u)^3 + 3\vec{P}_1u(1-u)^2 + 3\vec{P}_2u^2(1-u) + \vec{P}_3u^3$$



voir cours NSY116 (chapitre sur les techniques graphiques 2D)

## Primitive bezier() de Processing

```
void setup(){  
  size(600,600);  
  noFill();  
  strokeWeight(3);  
}  
  
void draw(){  
  background(0,0,0);  
  stroke(255,100,0);  
  line(255, 260, mouseX, mouseY);  
  line(mouseX, mouseY, 270, 470);  
  line(270,470, 45, 440);  
  
  stroke(255);  
  bezier(255,260, mouseX, mouseY, 270, 470, 45, 440);  
}
```



demo

## Spline de Catmull-Rom sous Processing :

Name

**curveVertex()**

Examples



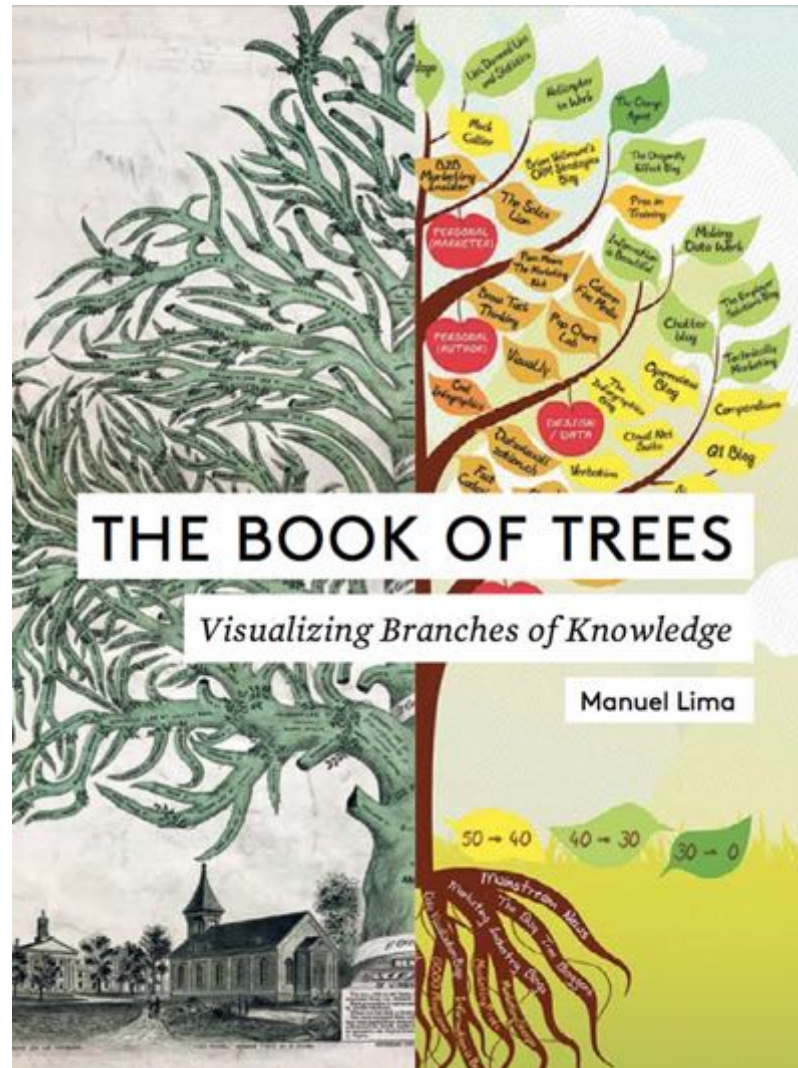
```
noFill();  
beginShape();  
curveVertex(84, 91);  
curveVertex(84, 91);  
curveVertex(68, 19);  
curveVertex(21, 17);  
curveVertex(32, 100);  
curveVertex(32, 100);  
endShape();
```

Description

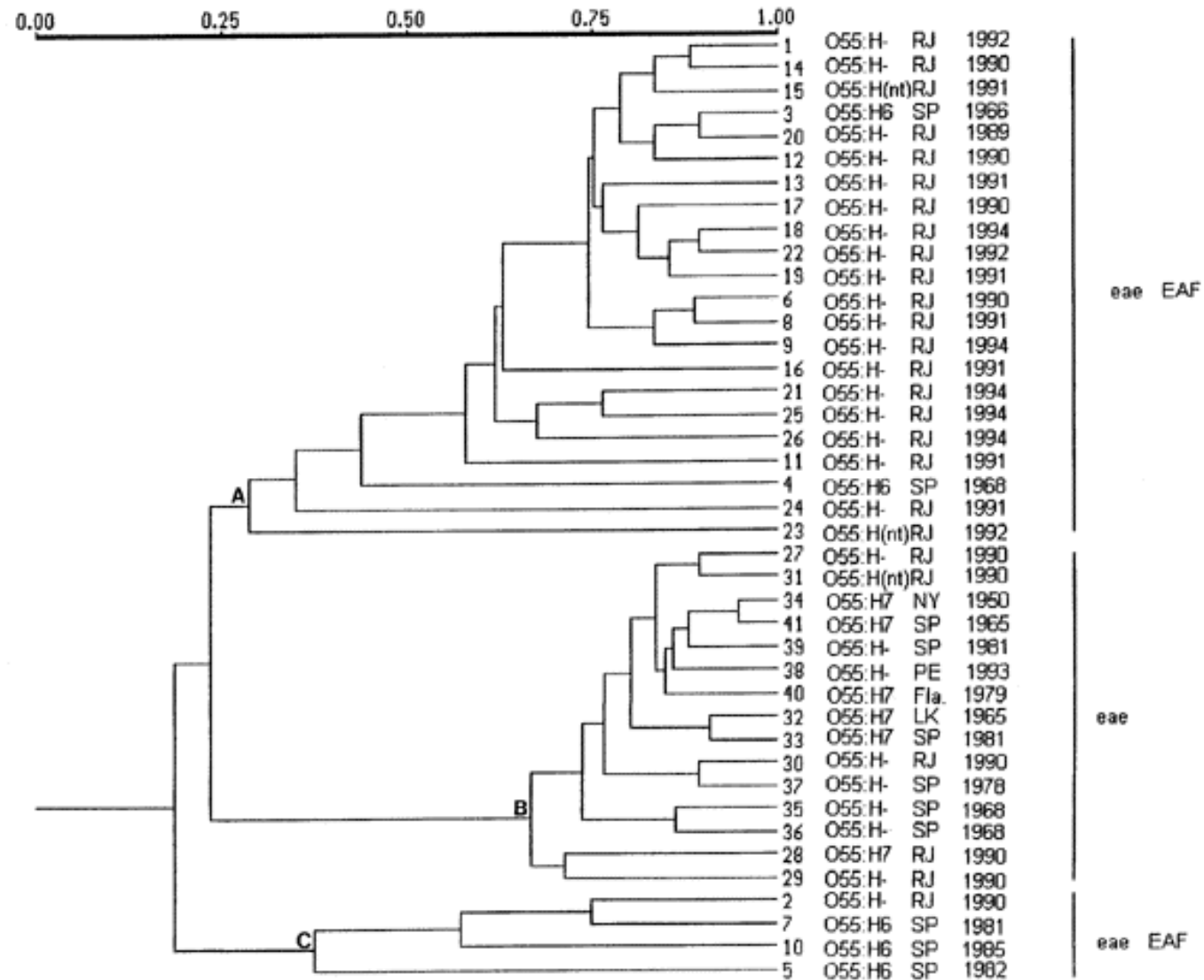
Specifies vertex coordinates for curves. This function may only be used between **beginShape()** and **endShape()** and only when there is no MODE parameter specified to **beginShape()**. The first and last points in a series of **curveVertex()** lines will be used to guide the beginning and end of the curve. A minimum of four points is required to draw a tiny curve between the second and third points. Adding a fifth point with **curveVertex()** will draw the curve between the second, third, and fourth points. The **curveVertex()** function is an implementation of Catmull-Rom splines. Using the 3D version of requires rendering with P3D or OPENGL (see the Environment reference for more information).



## 4. Les arbres



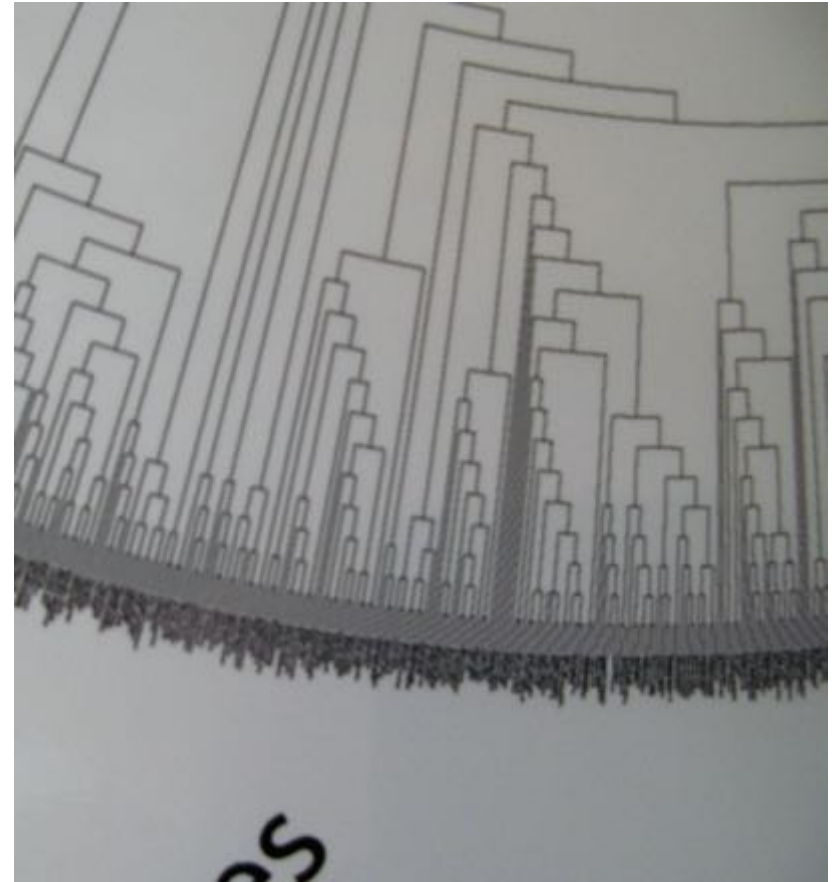
# Dendrogrammes



## Représentations radiales

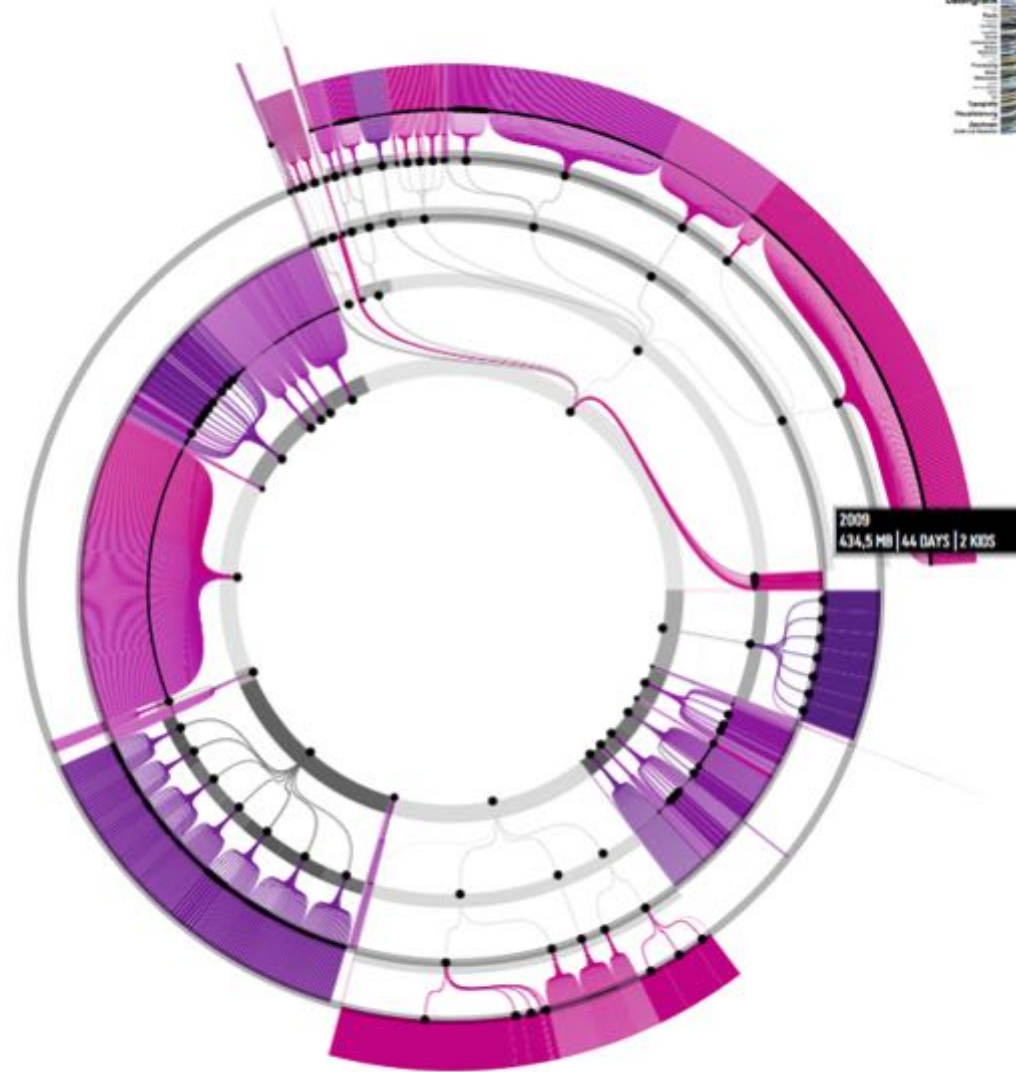


Un exemple : classer les  
espèces vivantes sur Terre



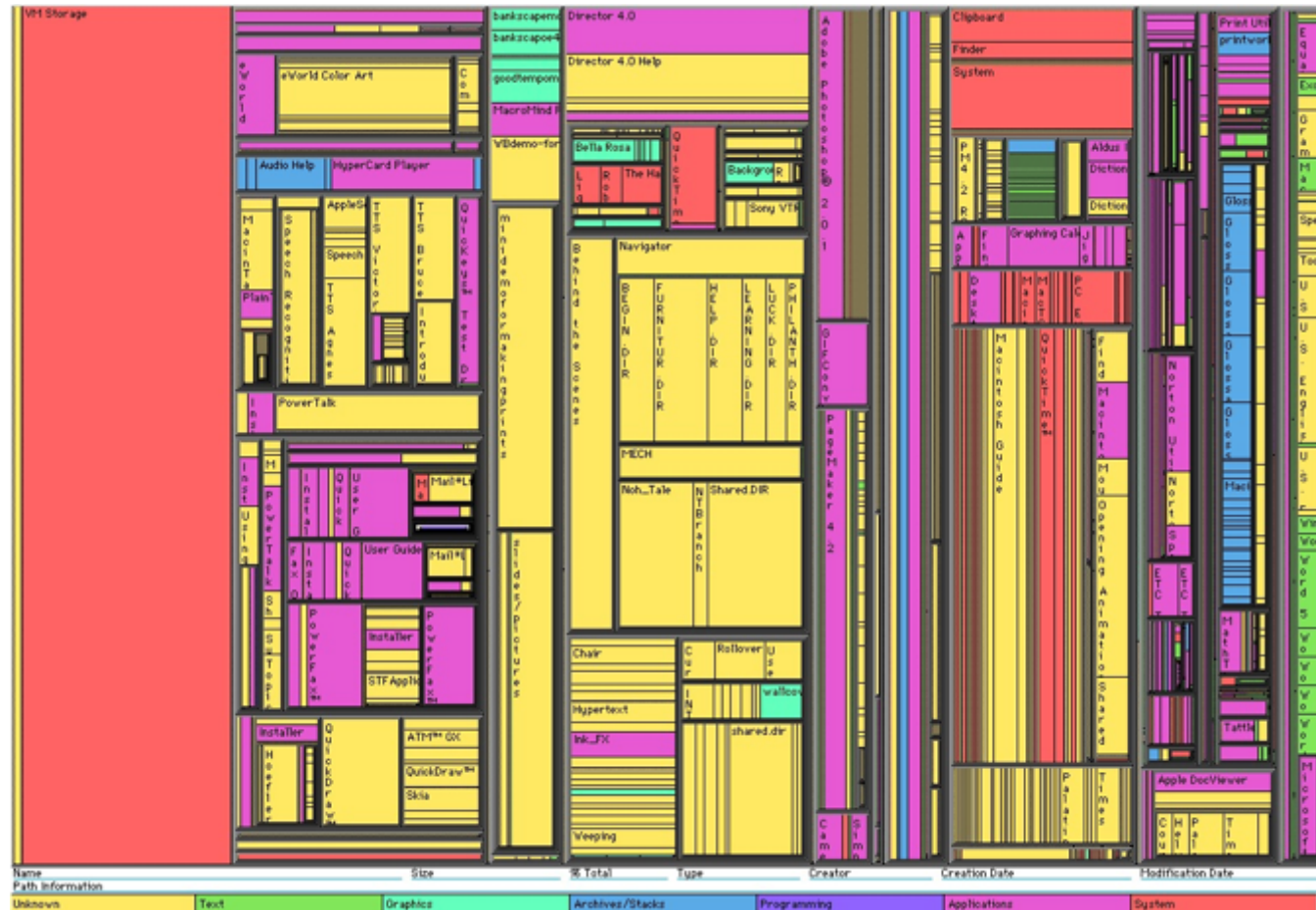
Panneau 1.50x1m env.  
Noms illisibles => IHM

## Chapitre M.5.0 de "Design génératif"



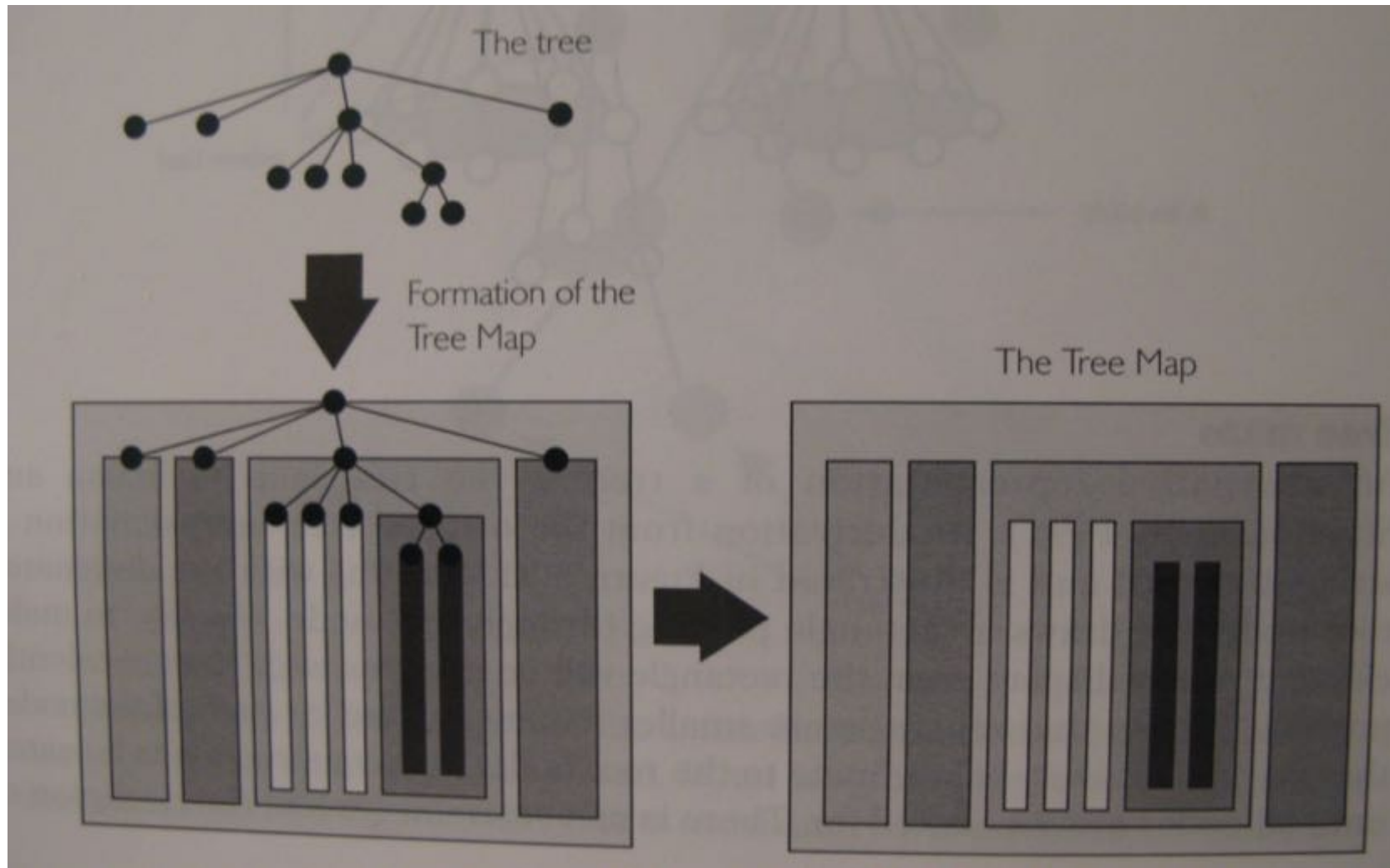
Programme Processing très complet (M\_5\_5\_01\_TOOL)

# Tree-maps (Johnson & Schneiderman, 1991)





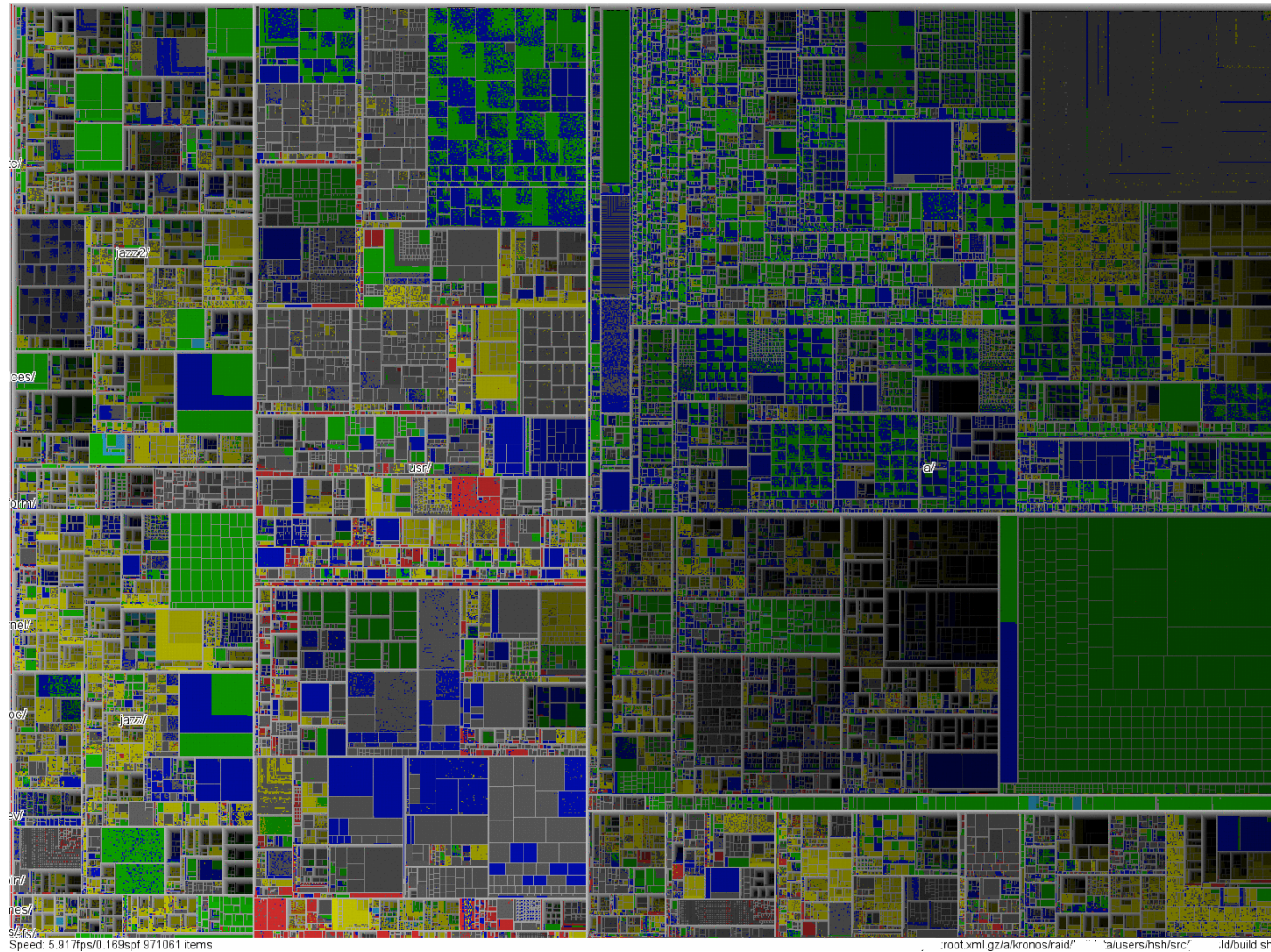
## Principe de la subdivision



[Spence p. 86]



# Treemap avec un million d'items (Fekete, Plaisant – 2002)



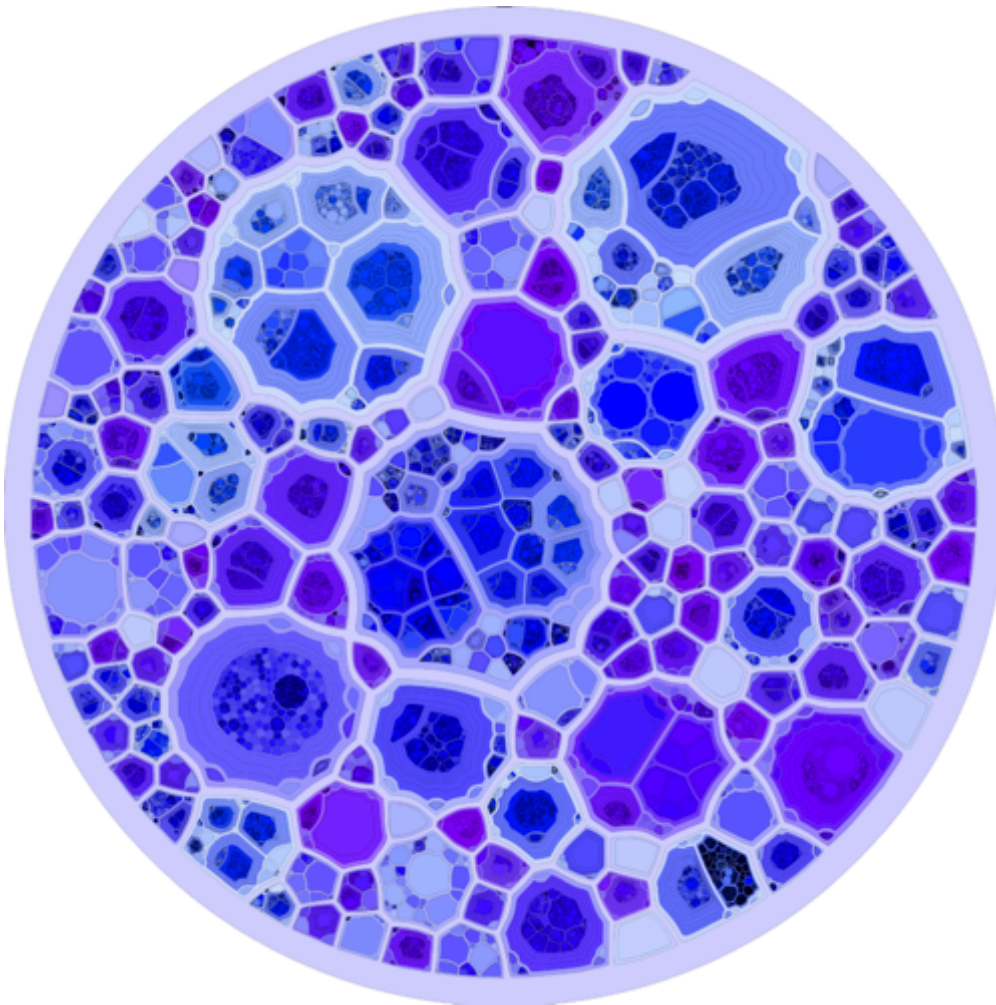
code source et infos : <http://www.cs.umd.edu/hcil/millionvis/>

## Autre exemple : newsmap

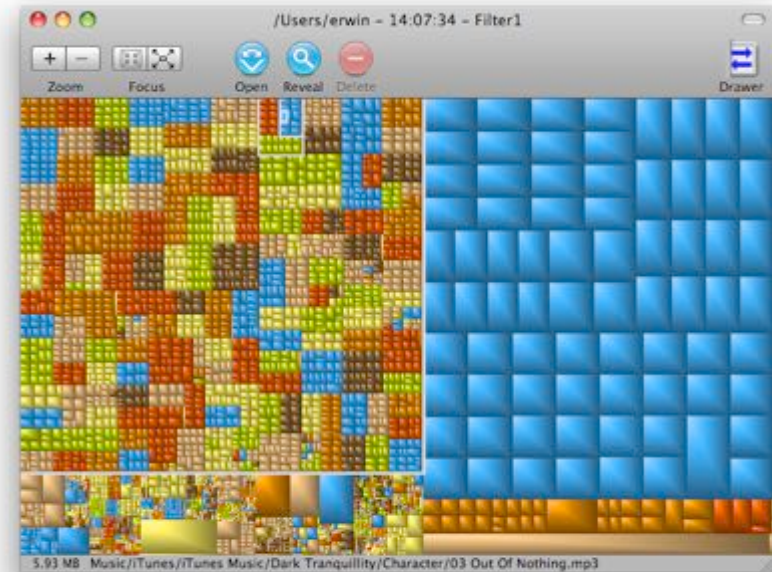




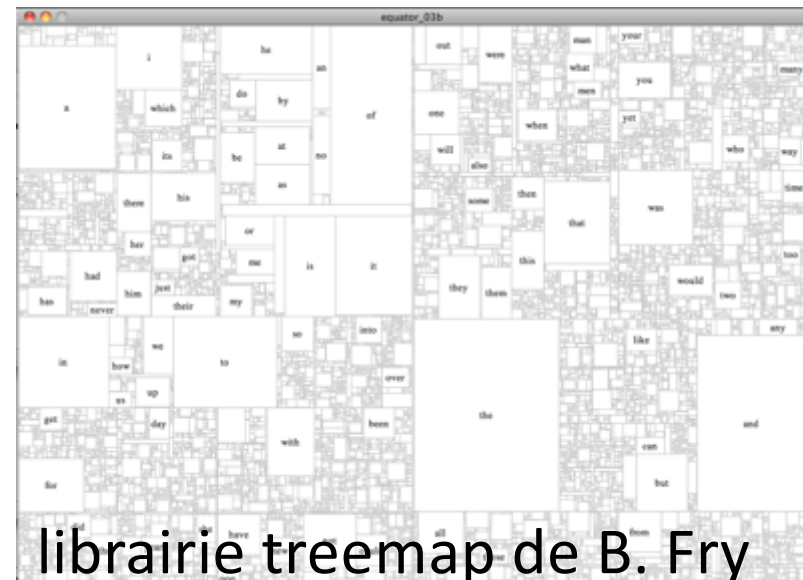
# Nombreuses variantes



<http://www.informatik.uni-konstanz.de/deussen/mitarbeiter/oliver-deussen/olivers-kunstversuche/>



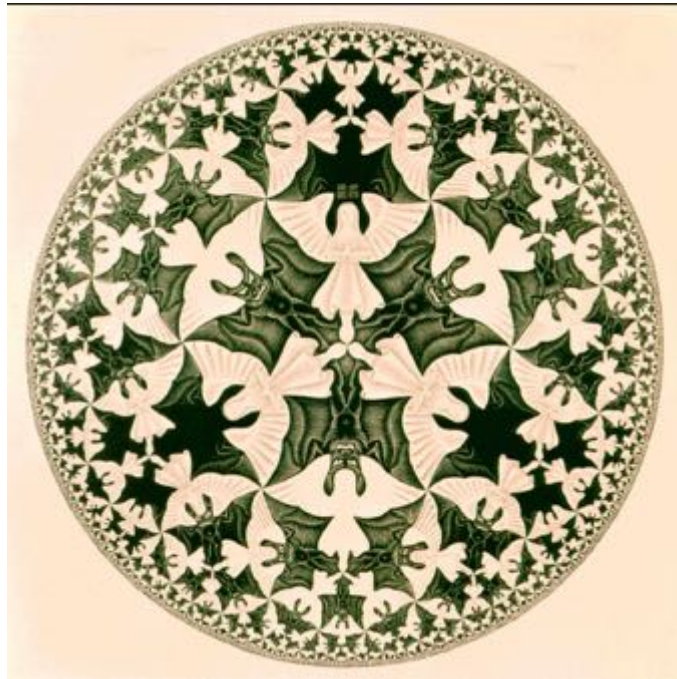
<http://grandperspectiv.sourceforge.net/>



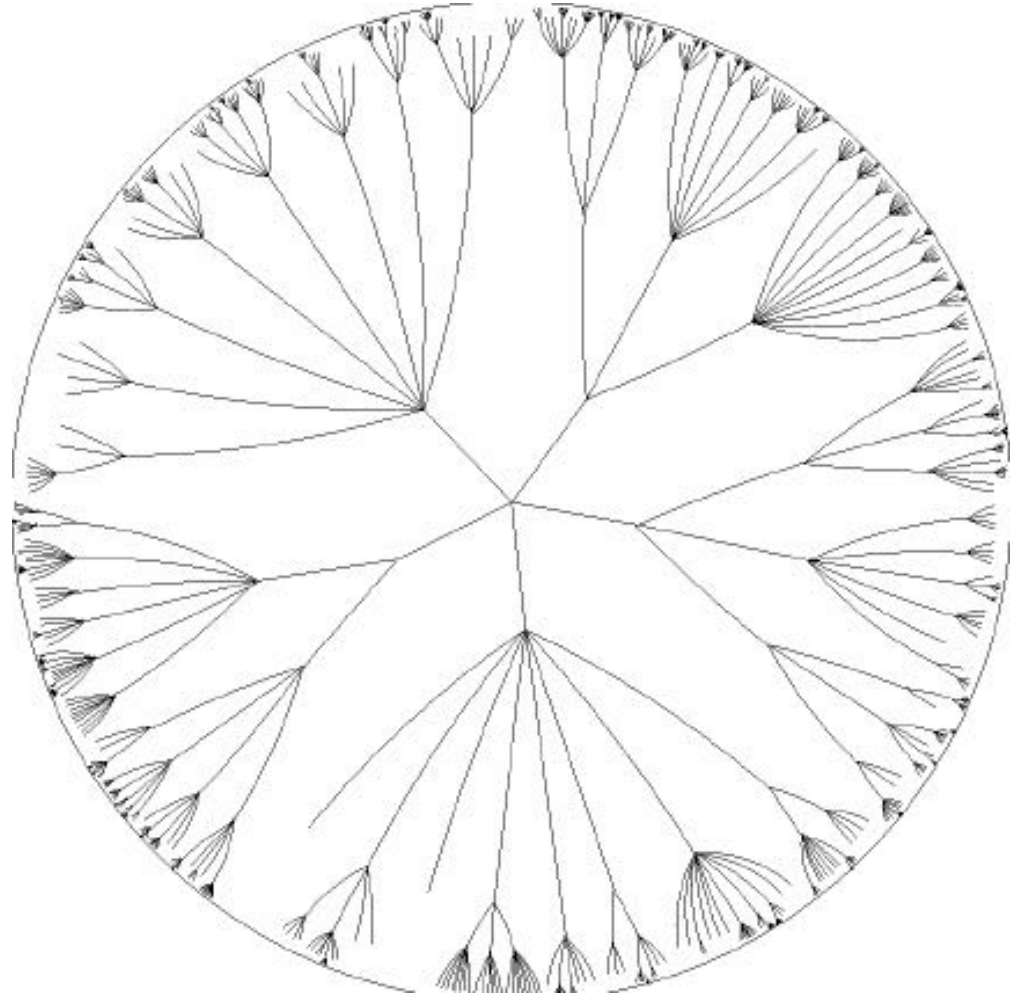
librairie treemap de B. Fry  
pour Processing

# Arbres hyperboliques (Lamping & Rao, 1995)

Inspiré d' Escher



<http://www.mcescher.com/Gallery/recogn-bmp/LW436.jpg>



[http://www.infovis-wiki.net/index.php?title=Image:Hypmtree\\_original.jpg](http://www.infovis-wiki.net/index.php?title=Image:Hypmtree_original.jpg)

1004 sommets, distrib. Poissonienne du nbre de fils





... Abb. 11b: Hyperbolic Trees (2) ... Abb. 11a: Hyperbolic Trees (1)

385 x 395 - 10 ko - gif  
[coli.lili.uni-bielefeld.de](http://coli.lili.uni-bielefeld.de)



411 x 437 - 12 ko - gif  
[coli.lili.uni-bielefeld.de](http://coli.lili.uni-bielefeld.de)

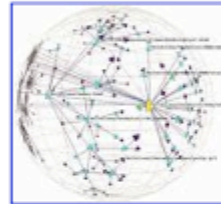
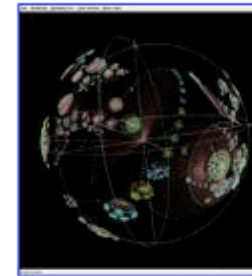
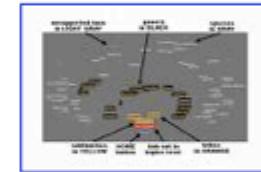


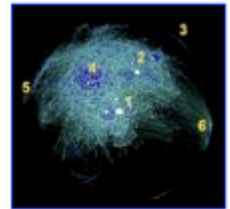
Figure 2-15: Hyperbolic tree.  
 336 x 308 - 50 ko - gif  
[www3.sympatico.ca](http://www3.sympatico.ca)



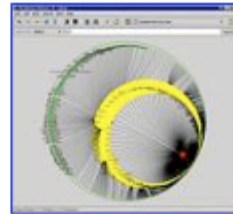
Hyperbolic geometry: Spectacular  
 888 x 964 - 198 ko - png  
[www.infovis.net](http://www.infovis.net)



CGDP - HYPERBOLIC TREE  
 KEY  
 600 x 404 - 31 ko - gif  
[www.filmnh.ufl.edu](http://www.filmnh.ufl.edu)



... are two more hyperbolic tree  
 300 x 288 - 111 ko - jpg  
[dd.dynamicdiagrams.com](http://dd.dynamicdiagrams.com)



... Eye or Hyperbolic Tree Viewer  
 is ...  
 400 x 368 - 58 ko - gif  
[www.sorice.com](http://www.sorice.com)



Hyperbolic Tree  
 350 x 339 - 76 ko - png  
[vw.indiana.edu](http://vw.indiana.edu)



Tree Text: Hyperbolic Tree  
 729 x 743 - 174 ko - jpg  
[www.itl.nist.gov](http://www.itl.nist.gov)



... zum Begriff "Hyperbolic Tree"  
 864 x 804 - 16 ko - png  
[beat.doebe.li](http://beat.doebe.li)

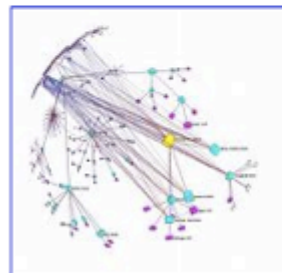
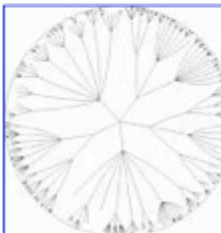


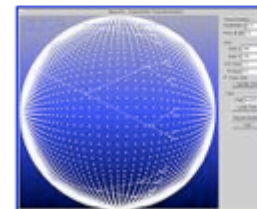
Figure 3-19: Non-tree links



Hyperbolic trees - InfoVis-Wiki



an original hyperbolic tree with



Hyperbolic Tree Visualization

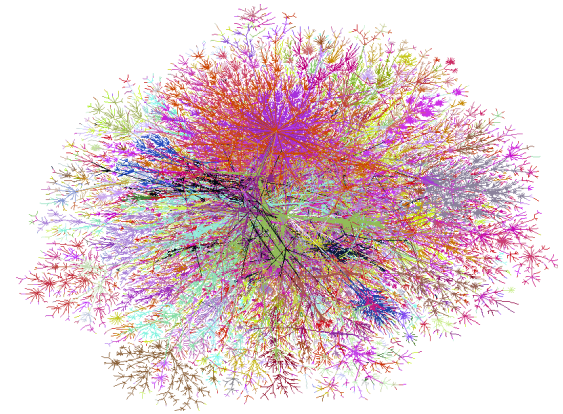


We will use the hyperbolic tree

## 5. Les graphes généraux



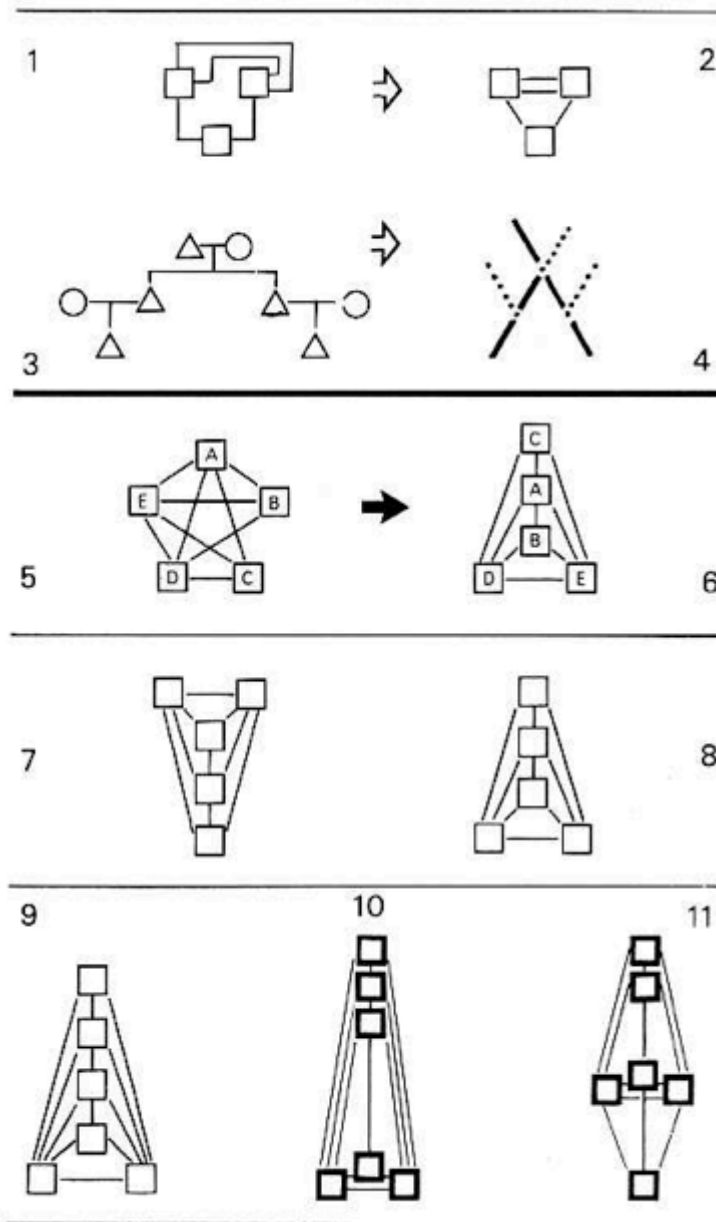
[wikipedia – article Ramen]



(image Lumeta  
vue cours #1)



# Dessiner un graphe ?



Simplicité  
du dessin

TRANSFORMATION

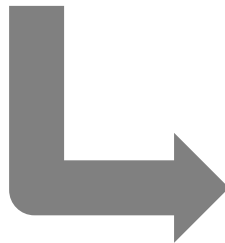
Simplicité de  
disposition

Ordre significatif

Groupe-  
ments  
significatifs

[Bertin2]

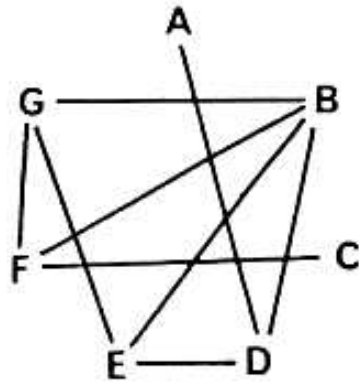
# Harry Beck et le plan du métro de Londres (1933)



## Dessin automatisé

### Méthode semi-manuelle (?) de Bertin

19



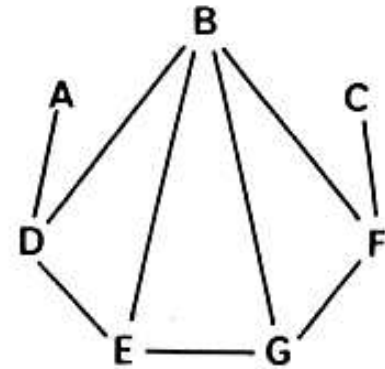
20

	A	B	C	D	E	F	G
A	A			●			
B		B		●	●	●	●
C			C			●	
D	●	●		D	●		
E		●		●	E		●
F		●	●			F	●
G		●			●	●	G

21

	A	D	E	B	G	F	C
A	A	●					
D	●	D	●	●			
E		●	E	●	●		
B		●	●	B	●	●	
G			●	●	G	●	
F				●	●	F	●
C						●	C

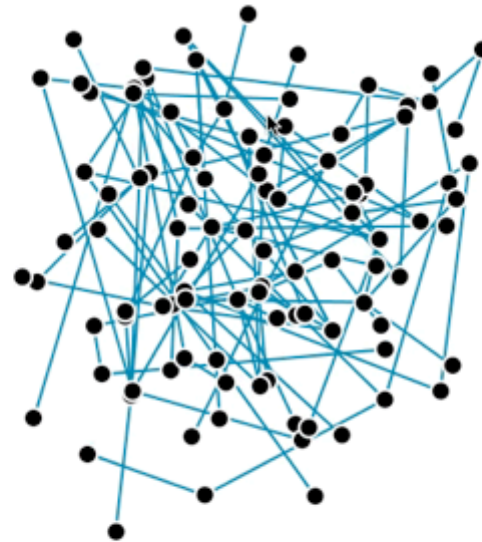
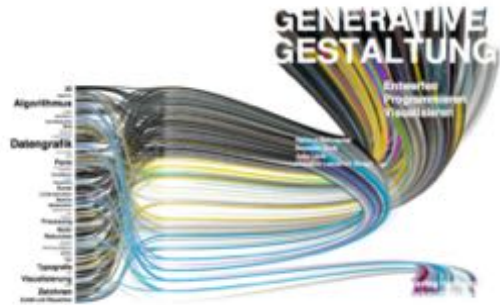
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Depuis : nombreux algorithmes

pour une revue : [http://en.wikipedia.org/wiki/Graph\\_drawing](http://en.wikipedia.org/wiki/Graph_drawing)

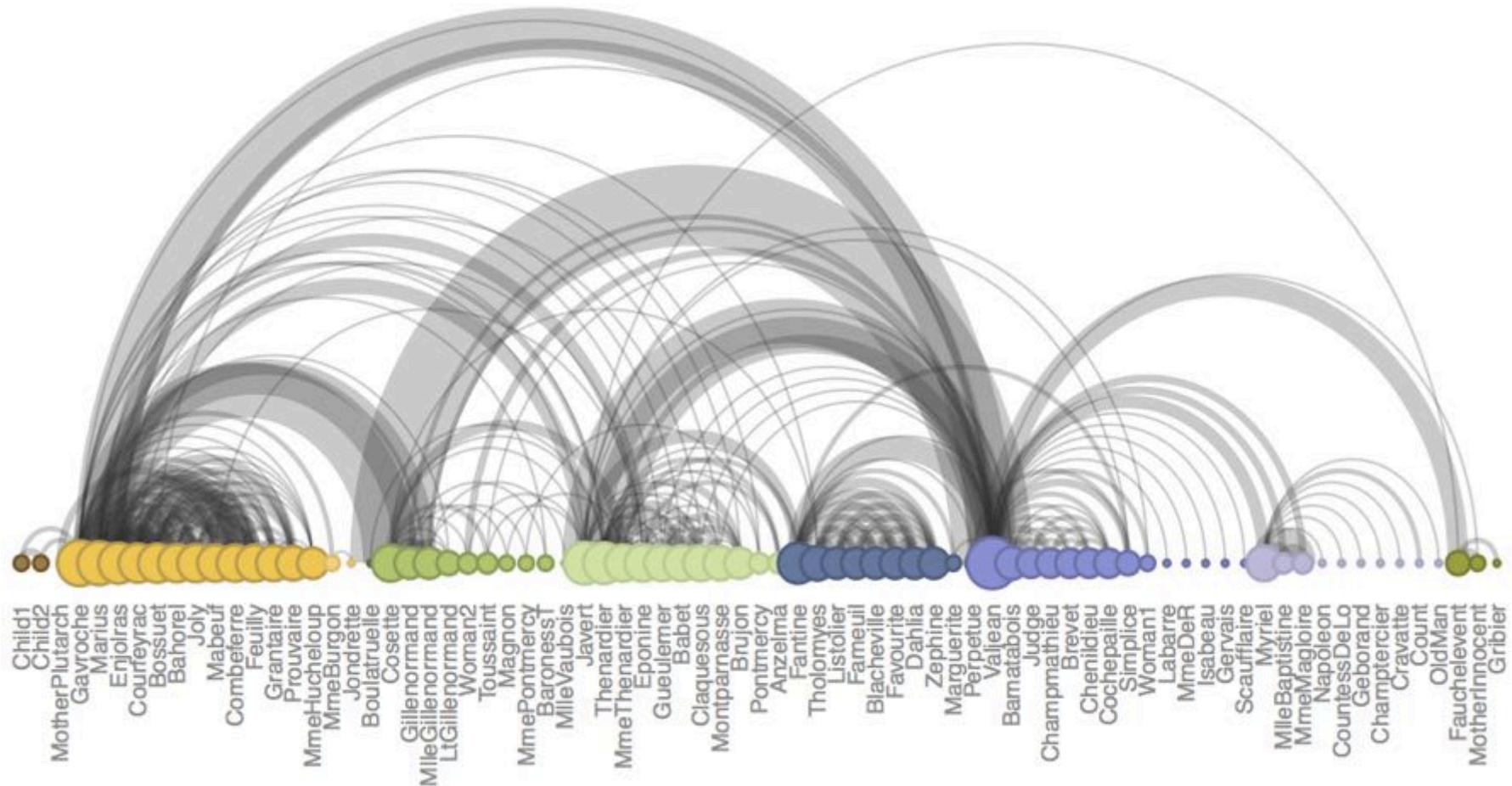
## Exemple extrait de "Design generatif" (prog. M\_6\_1\_03)



demo

# Représentations linéaires

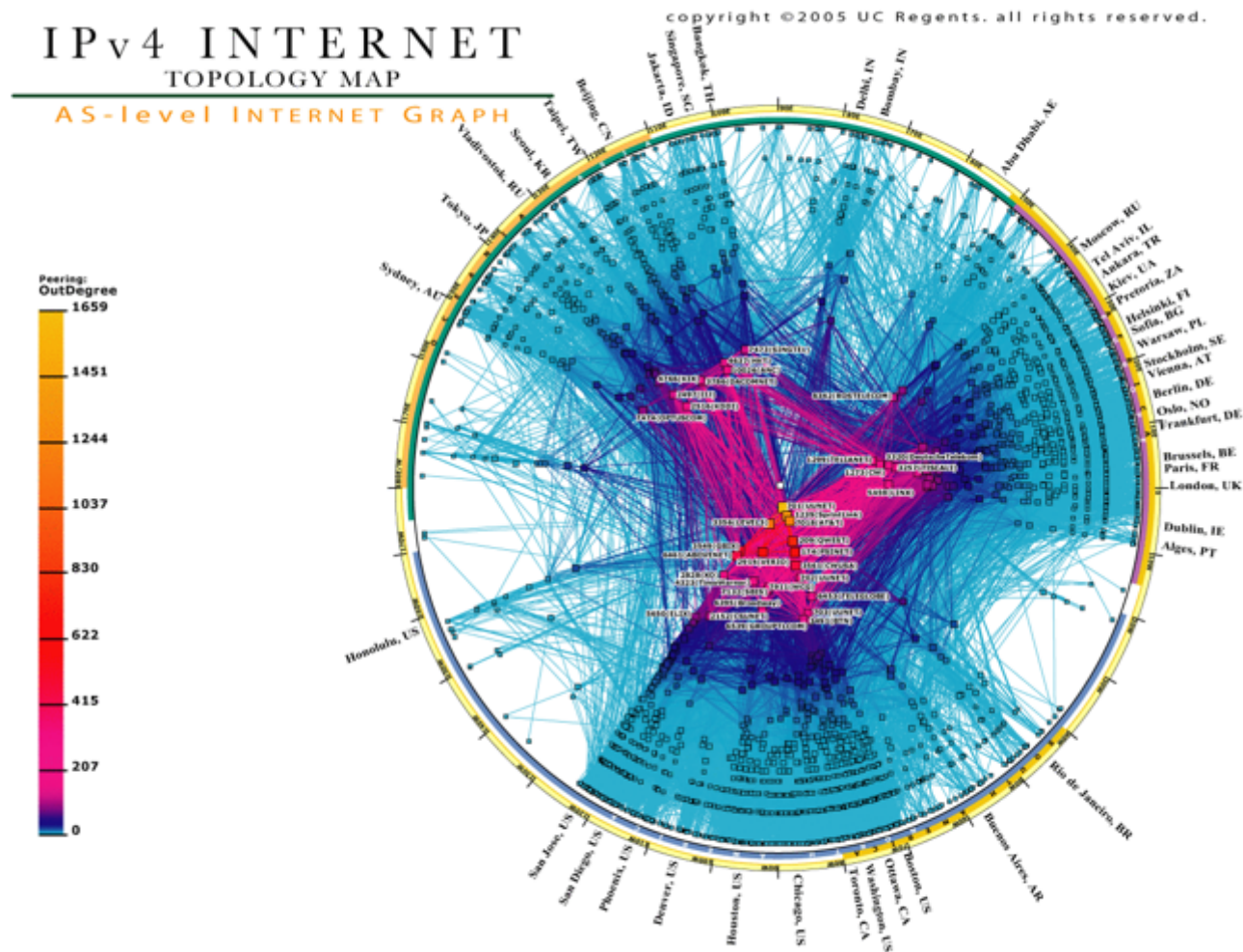
"arc diagrams"



<http://gastonsanchez.com/blog/got-plot/how-to/2013/02/02/Arc-Diagrams-in-R-Les-Miserables.html>




# Représentations radiales



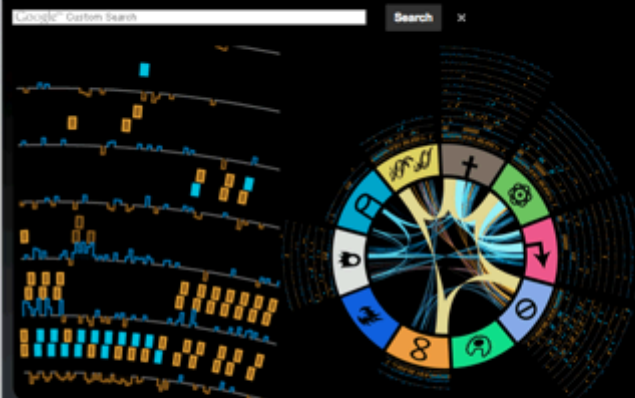
CAIDA : routage dans l'internet




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Circos is back for 3rd year at [2012 Bioinformatics and Comparative Genome Analysis](#) course by the Pasteur Institute—May 9



### CIRCOS, LUNG CANCER AND SMOKING

Imielinski et al visualize mutations in the exome and genome sequences of 183 lung adenocarcinomas to reveal recurrent somatic mutations in the splicing factor gene *U2AF1* and *RBM10* and *ARID1A*, as well as *EGFR* and *SRK2*. Grouping the data revealed clusters that correlated with smoking history.

Imielinski M, Berger AM, Hammerman PS et al (2008) Mapping the hallmarks of lung adenocarcinoma with massively parallel sequencing. *Cell* 150:1037–1050.

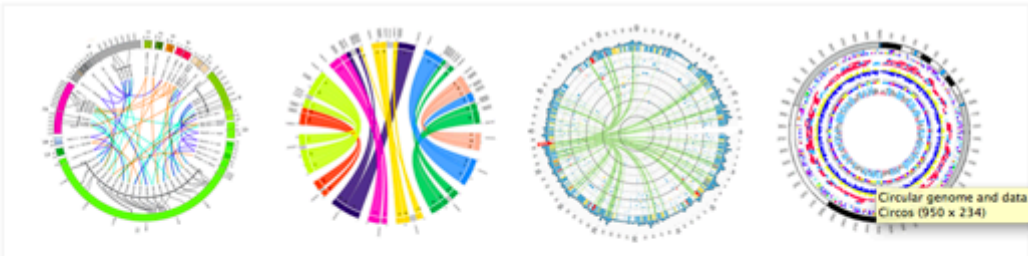
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## WHAT IS CIRCOS?

### CIRCULAR VISUALIZATION

Circos is a software package for [visualizing data and information](#). It visualizes data in a [circular layout](#) — this makes Circos ideal for exploring relationships between objects or positions. There are [other reasons](#) why a circular layout is advantageous, not the least being the fact that it is attractive.

Circos is ideal for creating publication-quality infographics and illustrations with a high [data-to-link ratio](#), richly layered data and pleasant symmetries. You have fine control each element in the figure to tailor its focus points and detail to your audience.



Circular genome and data visualization  
Circos (950 × 234)

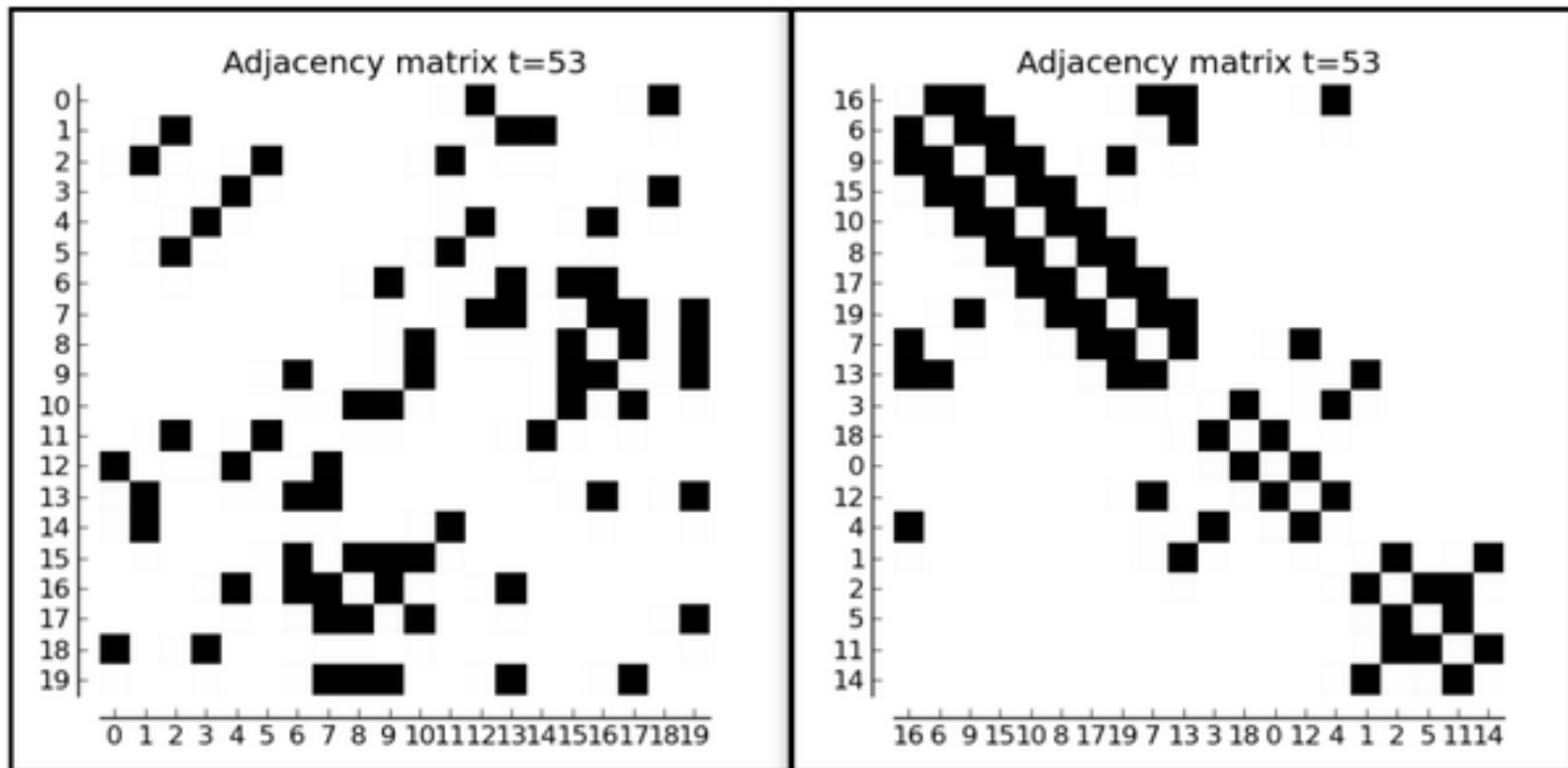
▲ Images created with Circos, illustrating links, ribbons, tiles and a variety of 2D data tracks. If it's round, Circos can probably do it ([more images](#)).

Circos is flexible. Although originally designed for [visualizing genomic data](#), it can create figures from [data in any field](#). If you have data that describes relationships or multi-layered annotations of one or more scales, Circos is for you.

Circos can be automated. It is controlled by plain-text configuration files, which makes it easily incorporated into data acquisition, analysis and reporting pipelines (a data pipeline is a multi-step process in which data is analyzed by multiple and typically independent tools, each passing their output as the input to the next step).

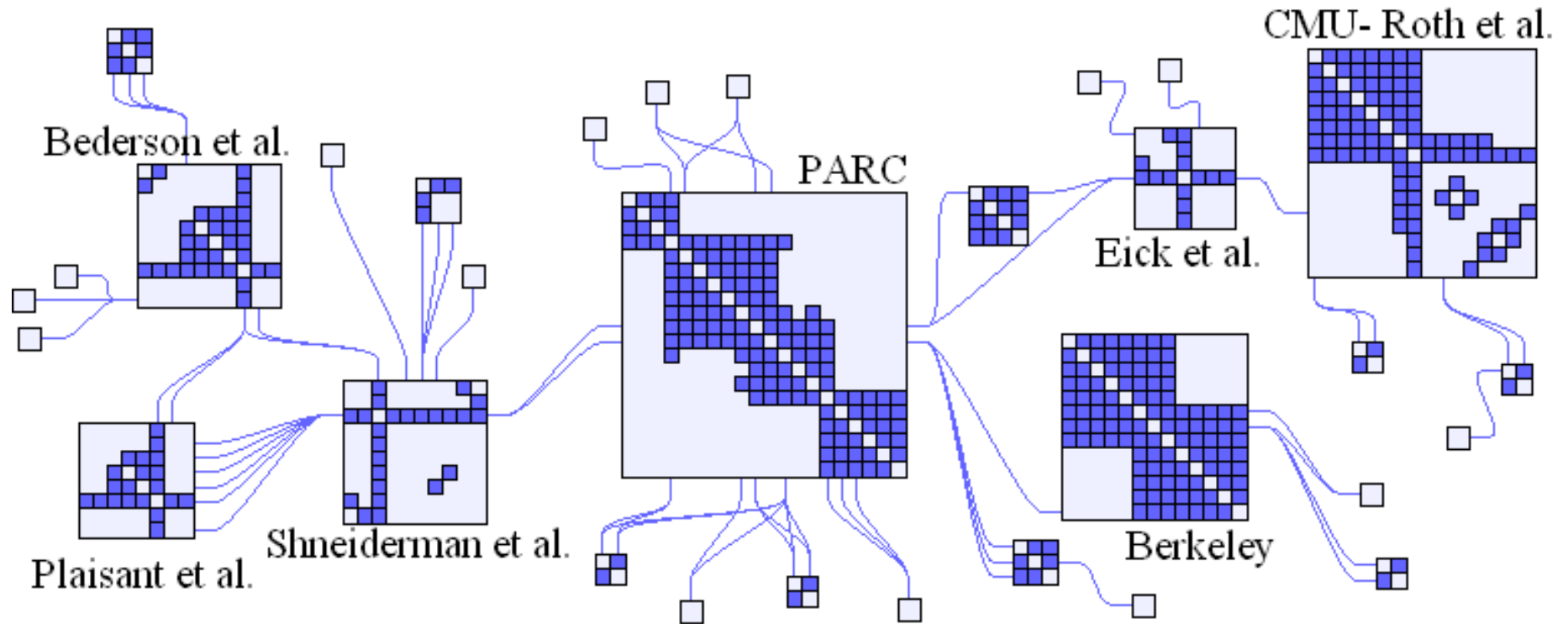
un logiciel <http://circos.ca>

## Matrice d'adjacence



<https://twitter.com/stefvandenelzen/status/520147126102556672>


## Approche mixte (graphe-matrice)



Equipe AVIZ de l'INRIA

<http://www.aviz.fr/wiki/pmwiki.php/Research/Nodetrix>

# Outils logiciels



## Graphviz - Graph Visualization Software

Envisioning connections

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### Graphviz Site Changes

Due to organizational changes, the Graphviz web site will see some modifications in the near future. In particular, it will probably no longer provide binary packages for Windows and Macs. The latter can be obtained via Macports or Home Brew. If someone wants to set up Appveyor for Windows, we would be grateful.


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Password: \*

### Graphviz

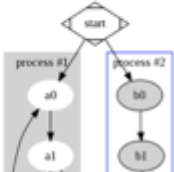


#### Welcome to Graphviz

**Available translations:** [Romanian](#), [Russian](#), [Russian \(more natural?\)](#), [Serbo-Croatian](#), [Bulgarian](#) [Home](#) and [About](#)

#### What is Graphviz?

Graphviz is open source graph visualization software. Graph visualization is a way of representing structural information as diagrams of abstract graphs and networks. It has important applications in networking, bioinformatics, software engineering, database and web design, machine learning, and in visual interfaces for other technical domains.



#### Active forum topics

- [I need a direction is someone could help](#)
- [compilation issue on slackware 14.1](#)
- [graphviz linking to qt](#)
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#### New forum topics

- [I need a direction is someone could help](#)
- [graphviz linking to qt](#)
- [compilation issue on slackware 14.1](#)
- [compiling cdt and cgraph on windows as static libraries](#)
- [Curved arrows](#)

### Gephi

Présentation de Gephi

- Projet open source démarré par des étudiants à UTC
- Outil de visualisation et d'analyse
- Écrit en Java, maintenu par une communauté large (développeurs seuls, entreprises, universités, etc.)
- <http://gephi.org>

le cnam

et Gephi (cf cours sur la fouille de graphe)