The Value of Visualization

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CS 294-10: Visualization
Fall 2007

Final Poster

Monday Dec 10, 10:30-Noon BID Lab
Poster 40x30" should include

- Problem
- Motivation
- Approach
- Results (bring a laptop to show demo)
- Future Work

Also prepare a 5 minute oral explanation/demo

- **Talk with Wesley Willett about printing**
- **PDF is best format – 40"(w) x 30"(h)**
- **PPT also works**
- **Thu 2-4pm, Fri 12-2pm**

Final Paper

Due: Friday, Dec 14 at midnight

Should be in the form of a research paper

- Follow IEEE Visualization, SIGGRAPH or CHI format
- 8-12 pages
- Include content commonly found in a research paper
- We've read lots of them in class

Topics

Animation

The value of visualization

Animation

Question

The goal of visualization is to convey information

How does *animation* help convey information?

Understanding Motion

Motion as a visual cue

Pre-attentive

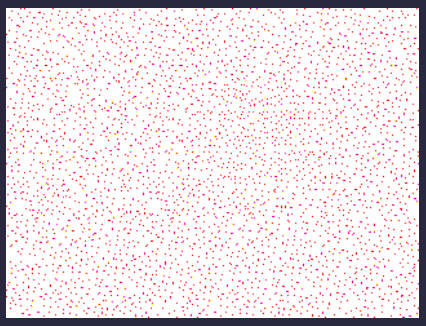
- Stronger than color, shape, …

More sensitive to motion at periphery

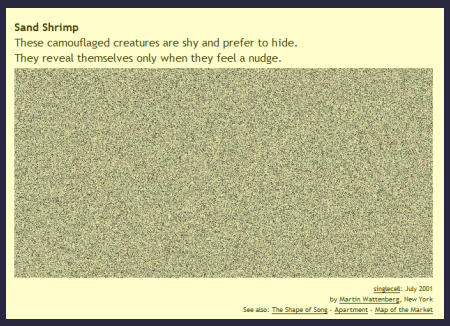
Triggers an orientation response

Motion parallax provide 3D cue (like stereopsis)

Segment by common motion (fate)

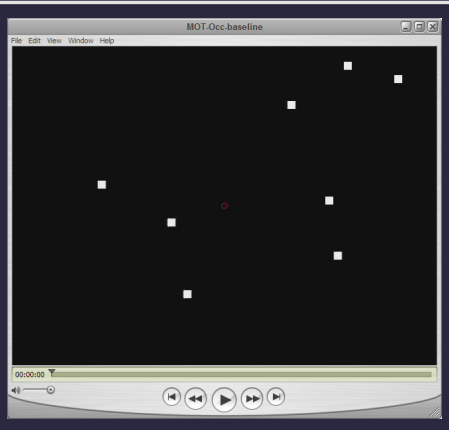


http://dragon.uml.edu/psych/commfate.html



http://www.singlecell.org/july/index.html

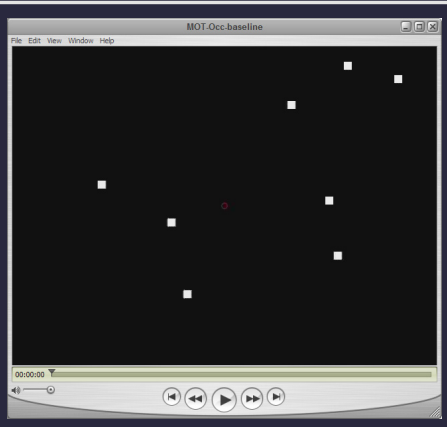
Tracking multiple targets



How many dots can we simultaneously track?

[Yantis 92, Pylyshn 88, Cavanagh 05]

Tracking multiple targets

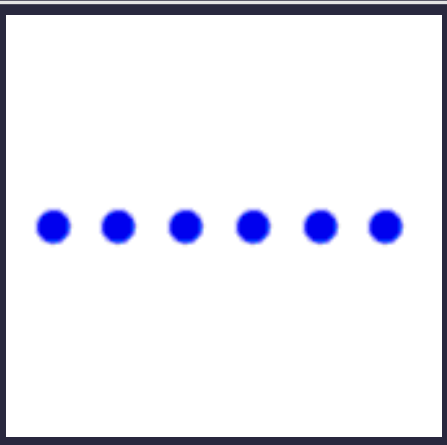


How many dots can we simultaneously track?

- **4 to 6 - difficulty increases significantly at 6**

[Yantis 92, Pylyshn 88, Cavanagh 05]

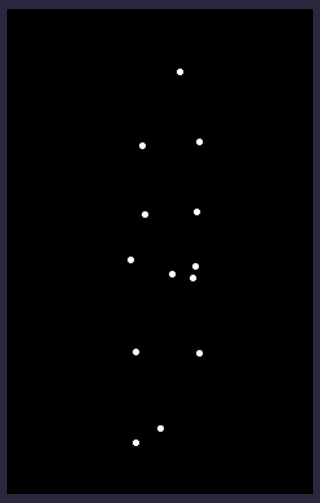
Grouped dots count as 1 object



Dots moving together are grouped

http://coe.sdsu.edu/eet/articles/visualperc1/start.htm

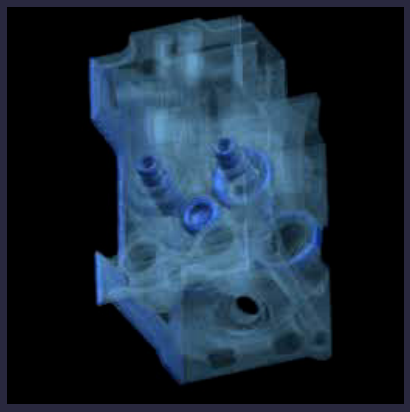
Grouping based on biological motion



[Johansson 73]

http://www.lifesci.sussex.ac.uk/home/George_Mather/Motion/

Motion parallax [Lacroute 95]



Video

Motions directly show transitions

Can see change from one state to next

- States are spatial layouts
- Changes are simple transitions (mostly translations)

start

Motions directly show transitions

Can see change from one state to next

- States are spatial layouts
- Changes are simple transitions (trans., rot., scale)

end

Motions directly show transitions

Can see change from one state to next

- States are spatial layouts
- Changes are simple transitions (trans., rot., scale)

start end

Shows transition better, but

- Still may be too fast, or too slow
- Too many objects may move at once

Show motion path in static image

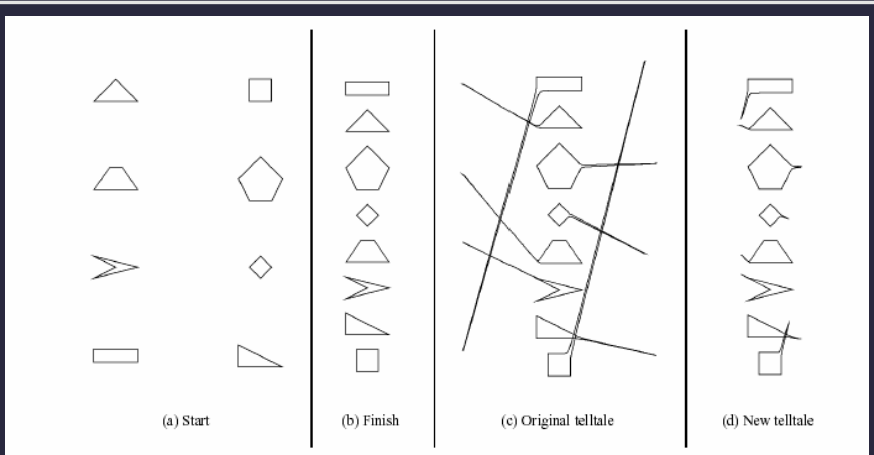
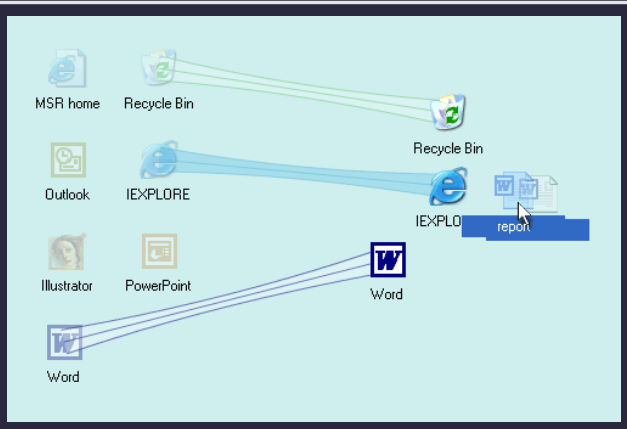


Figure 4. Example of the starting and finishing configurations for an alignment operation

Evaluation of Animation Effects to Improve Indirect Manipulation [Thomas 00]

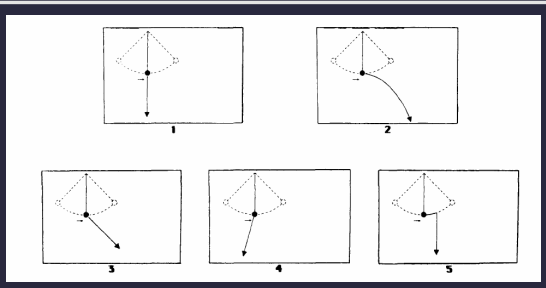
Drag-n-pop [Baudisch 03]



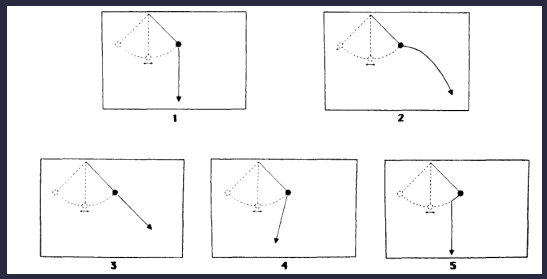
Relevant applications jump to file you are dragging with paths drawn as stretched bands (meant for large screen displays)

What about other transformations (rotation / scale)?

Intuitive physics [Kaiser 92]

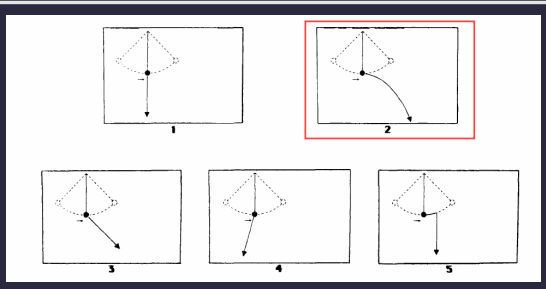


What is motion if string cut at *nadir* of motion?



What is motion if string cut at *apex* of motion?

Intuitive physics [Kaiser 92]



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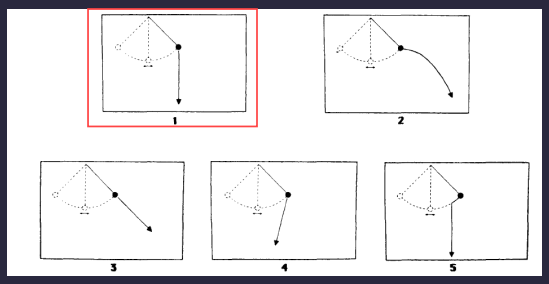

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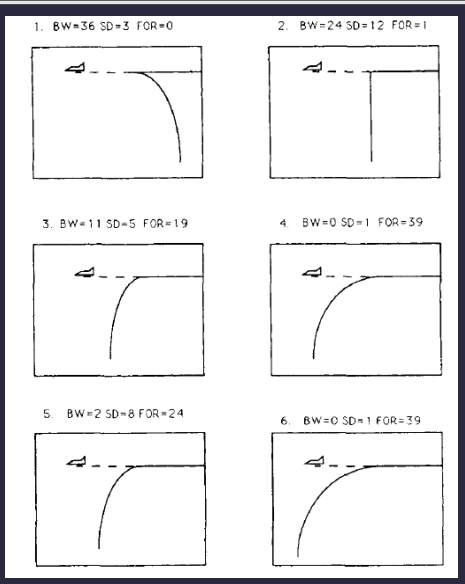

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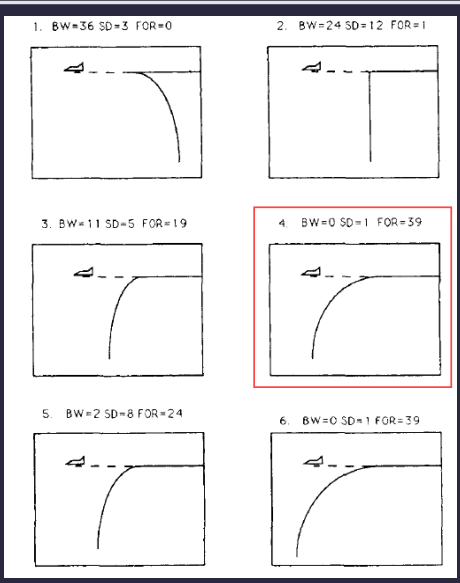
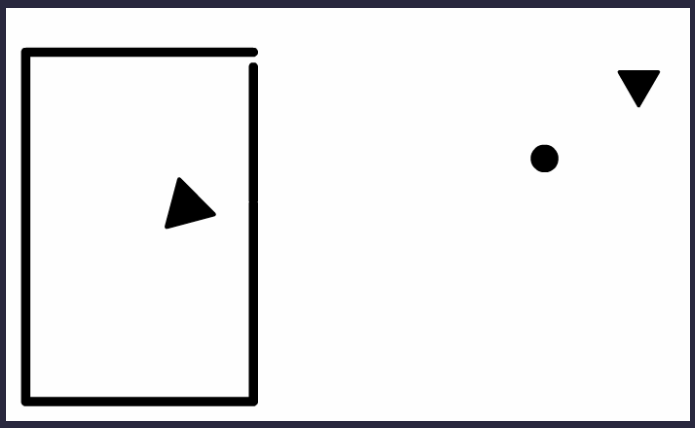


Seeing dynamic motion improves performance

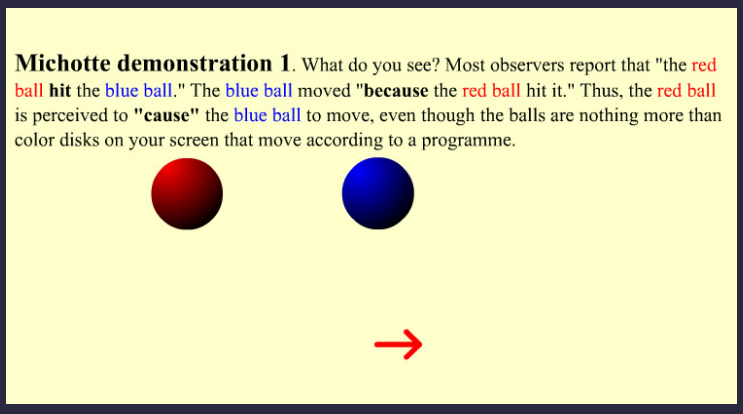
Interpreting Animation

Constructing narratives



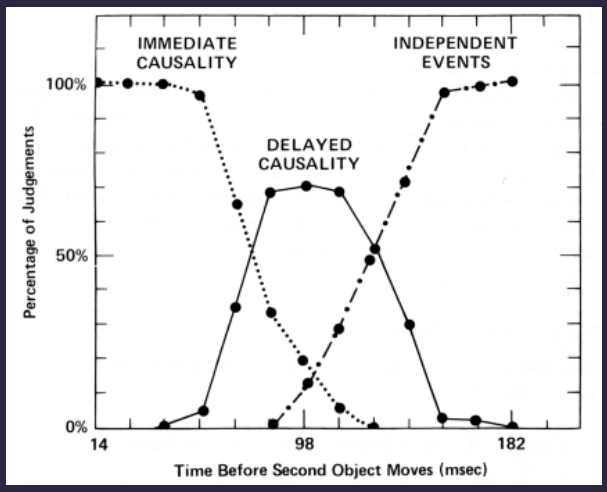
http://anthropomorphism.org/img/Heider_Flash.swf

Attribution of causality [Michotte 46]



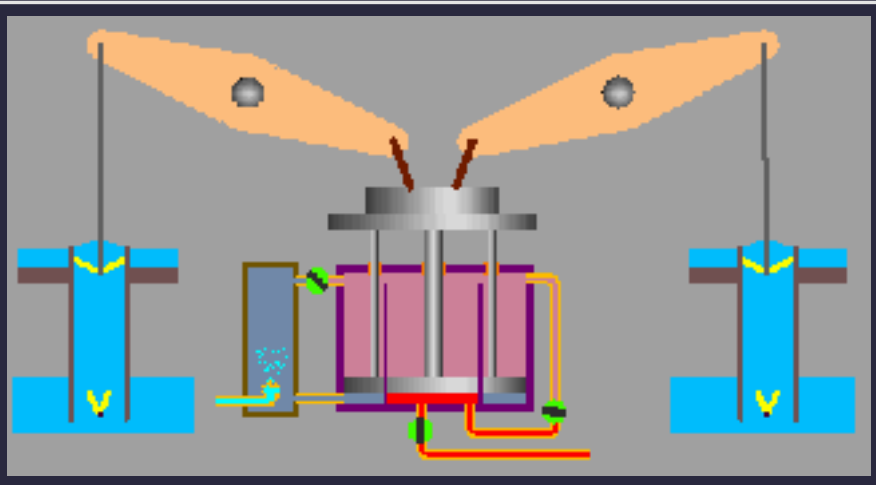
http://cogweb.ucla.edu/Discourse/Narrative/Heider_45.html

Attribution of causality [Michotte 46]

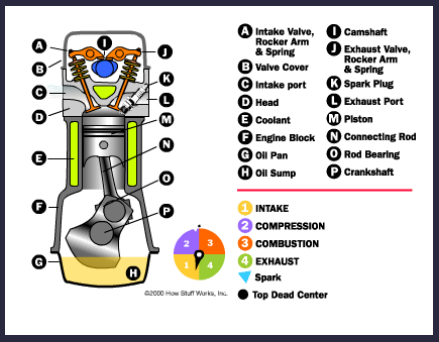


[Reprint from Ware 04]

How does it work?



Four-stroke combustion cycle



Q1: How many times does the piston go up and down per spark-plug firing?

Q2: What side does the fuel come in? What side does it exit?

Q2: How is the timing of the two valves coordinated?

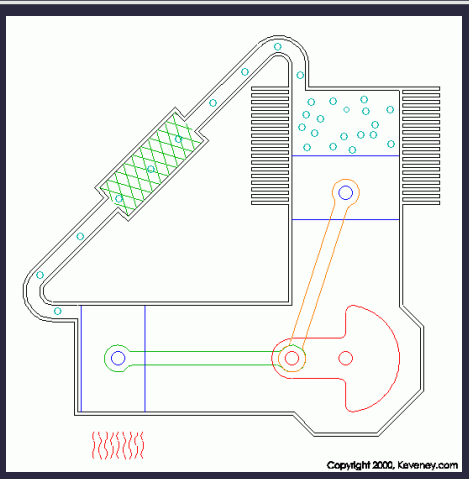
http://auto.howstuffworks.com/engine1.htm

Problems [Tversky 02]

Difficulties in understanding animation

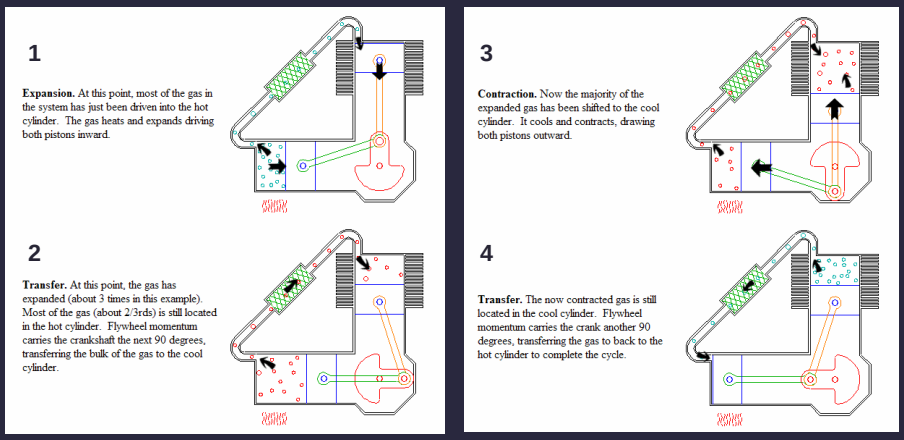
- Difficult to estimate paths and trajectories
- Motion is fleeting and transient
- Cannot simultaneously attend to multiple motions
- Trying to parse motion into events, actions and behaviors
- Misunderstanding and wrongly inferring causality
- Anthropomorphizing physical motion may cause confusion or lead to incorrect conclusions

Solution I: Break into static steps



Two-cylinder Stirling engine
http://www.keveney.com/Vstirling.html

Solution I: Break into static steps



Two-cylinder Stirling engine
http://www.keveney.com/Vstirling.html

Challenges

Choosing the set of steps

- How to segment process into steps? (see last lecture)
- Note: Steps often shown sequentially for clarity, rather than showing everything simultaneously

Tversky suggests

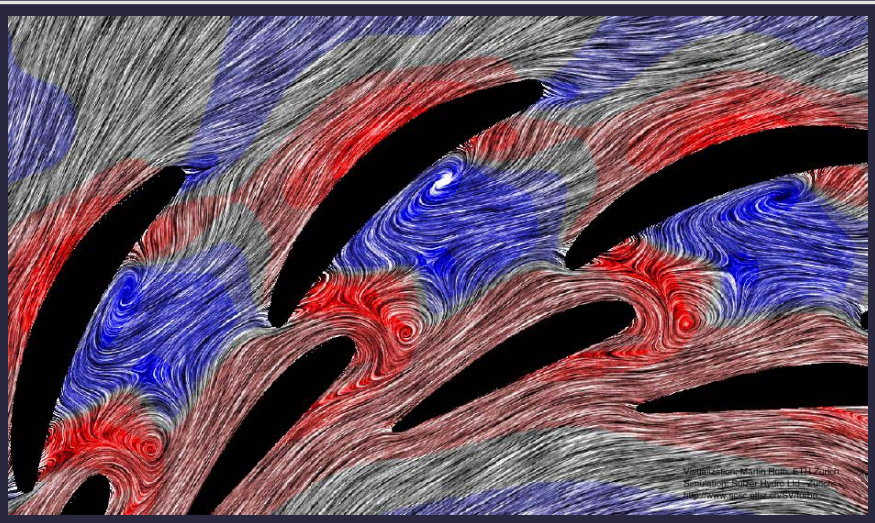
- Coarse level – segment based on objects
- Finer level – segment based on actions
  - Static depictions often do not show finer level segmentation

The Value of Visualization

Jarke van Wijk

Most new visualization research is not being used in the real-world. Why?

Example: Fluid flow



Line integral convolution [Cabral 93]

Most new visualization research is not being used in the real-world. Why?

Perhaps due to lack of proper assessment.

Standard measures

Effectiveness

Visualization should do what it is supposed to do

- Does it convey information?
- Does it decrease task time and/or error rate?
- Does it make it easier to make decisions?
- Other measures?

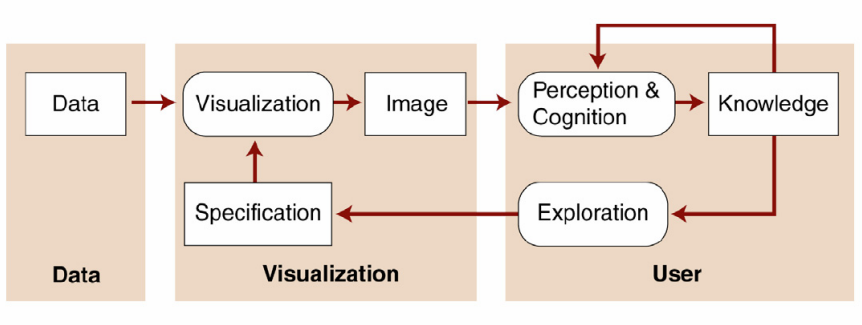
Efficiency

Visualization should use minimal resources

- Not always clear how to measure efficiency

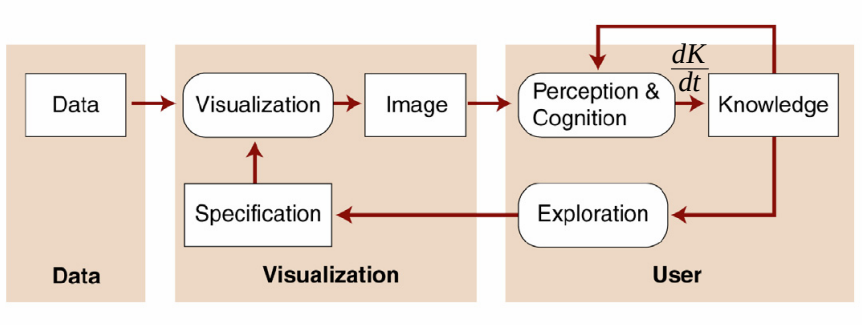
Implication is that visualizations should be judged in the context in which they are used

Generic model



$$I(t)=V(D,S,t)$$

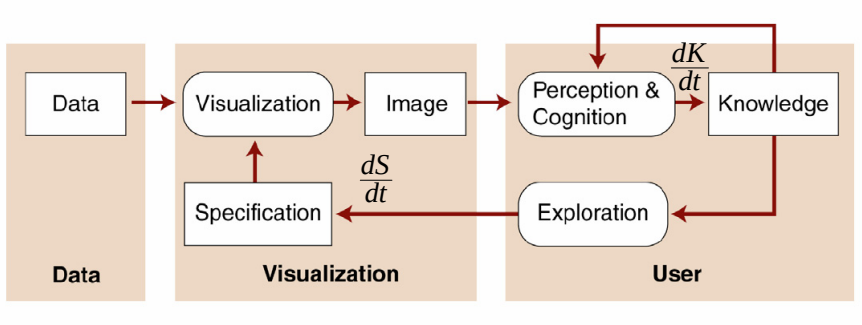
Generic model: Knowledge



$$\frac{dK}{dt}=P(I,K)$$

$$K(t)=K_0+\int_0^t P(I,K,t)dt$$

Generic model: Specification



$$\frac{dS}{dt} = E(K)$$

$$S(t) = S_0 + \int_0^t E(K)dt$$

Economic model

C_i: Initial development costs

C_u: Initial costs per user

C_s: Initial costs per session

C_e: Perception and exploration costs

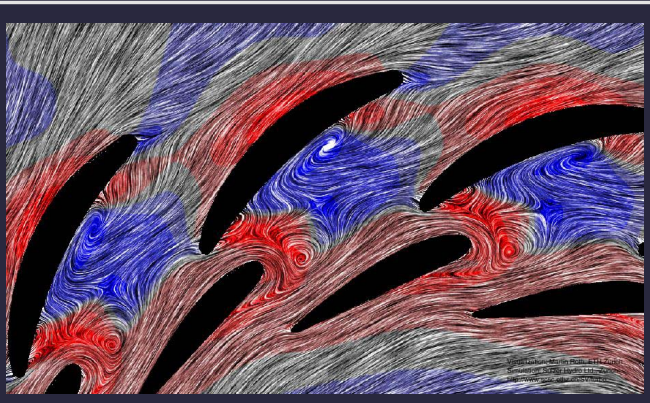
n users; *m* sessions; *k* explorative steps

$Cost = C_i + nC_u + nmC_s + nmkC_e$

$\Delta K = K(T) - K_0$

$Gain = nmW(\Delta K)$

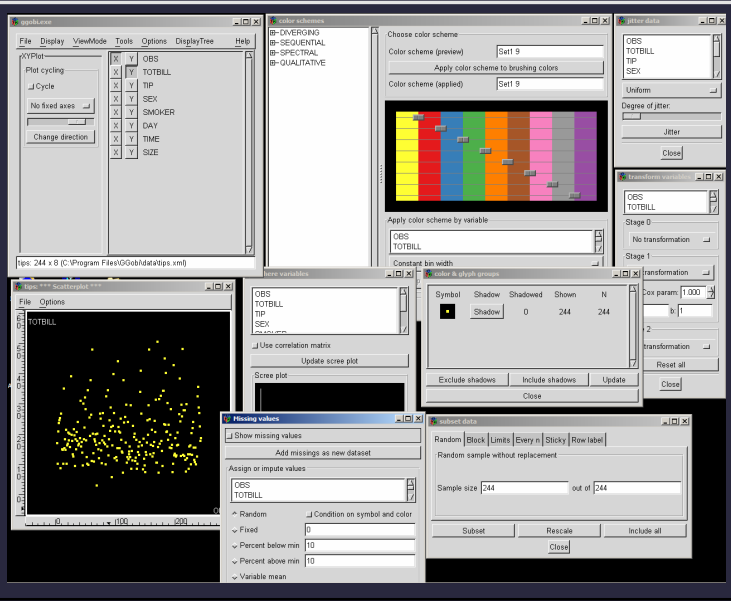
Case study: Line integral convolution



High initial costs C_u, low n, low m, very high K_0, ΔK unclear

- Visualization may not present most important quantities
- Often user is left to implement visualization technique
- User must learn how to use visualization effectively

Case study: Ggobi



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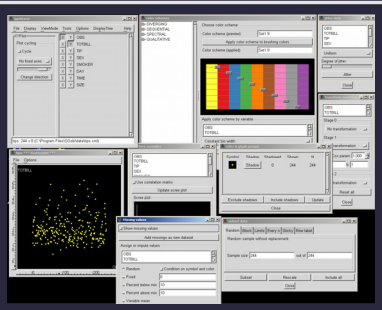


Interface is hard to learn

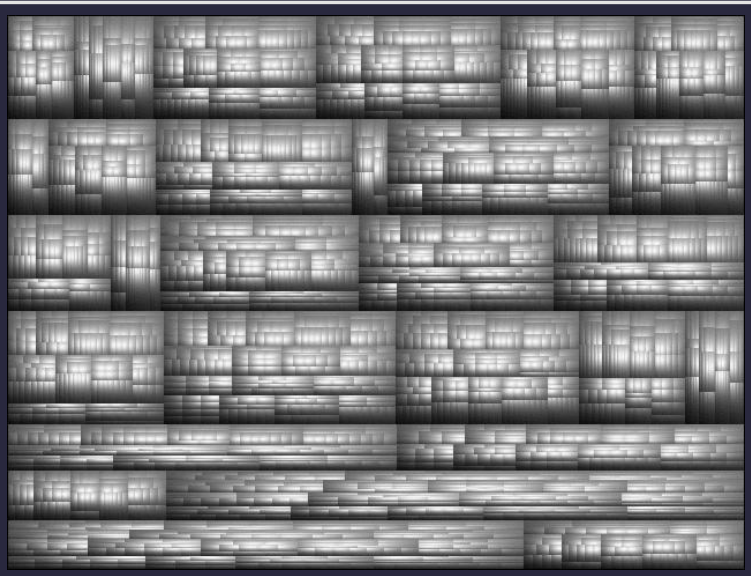
Specification process is subjective

- How can user know how to set specification when exploring

All the data may not be visible

Make all aspects customizable, but set good defaults

Case study: Cushion treemaps [van Wijk 99]



Case study: Cushion treemaps [van Wijk 99]

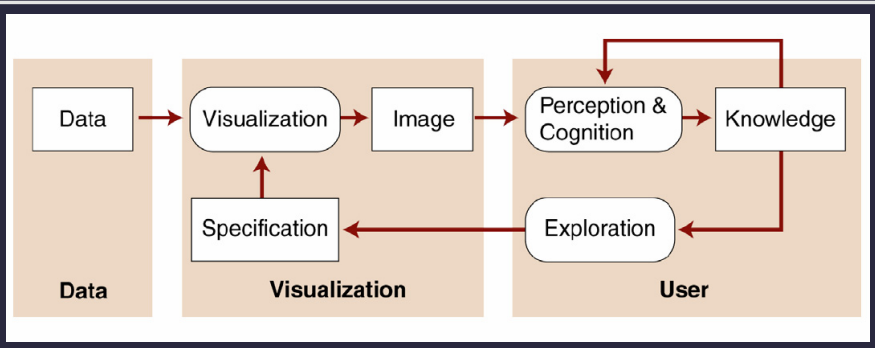
High n

Low m (several times a year) – not negligible (??)

Alternative methods scarce (??)

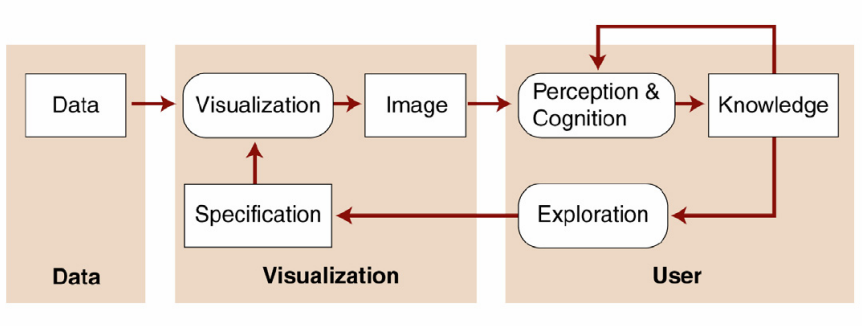
Initial costs low (??)

Issues with the model



What is it missing?

Issues with the model



What is it missing?

- Efficiency measures
- Perceived benefits in minds of users
- Entrenched methods
- Artistic value

Summary

Need to design and analyze visualization techniques in context of real-world use

The future of visualization

Where is more work required?

What technologies will impact visualization design?

What did you find most difficult in creating visualizations and designing visualization techniques?