

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

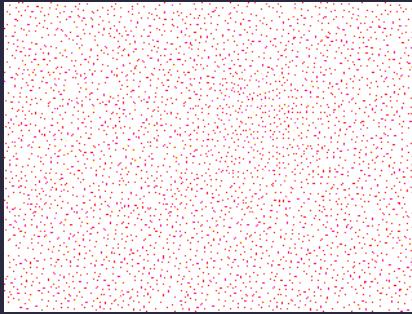
- Stronger than color, shape, ...

More sensitive to motion at periphery

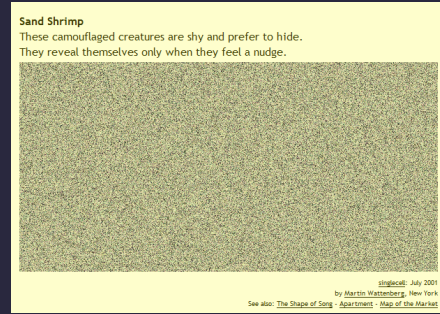
Triggers an orientation response

Motion parallax provide 3D cue (like stereopsis)

Segment by common motion (fate)

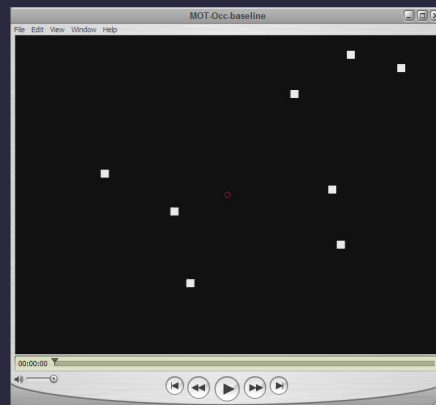


<http://dragon.uml.edu/psych/commfate.html>



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

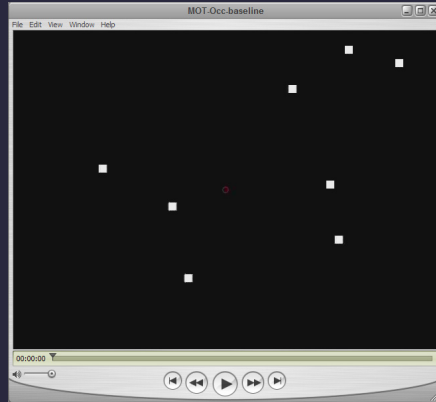
Tracking multiple targets



How many dots can we simultaneously track?

[Yantis 92, Pylyshn 88, Cavanagh 05]

Tracking multiple targets

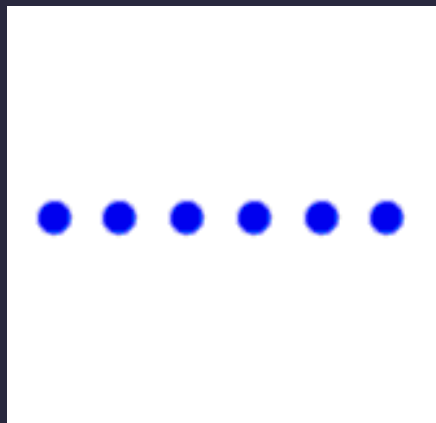


How many dots can we simultaneously track?

- 4 to 6 - difficulty increases significantly at 6

[Yantis 92, Pylyshn 88, Cavanagh 05]

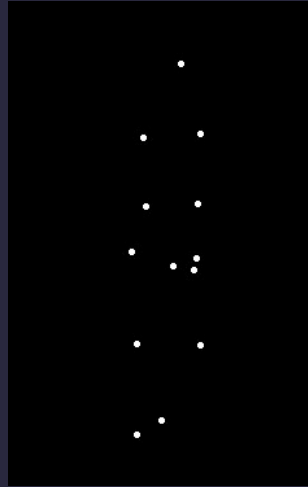
Grouped dots count as 1 object



Dots moving together are grouped

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

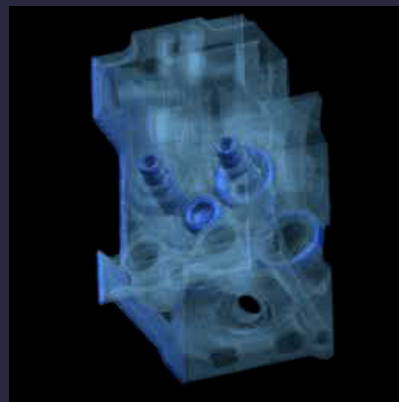
Grouping based on biological motion



[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

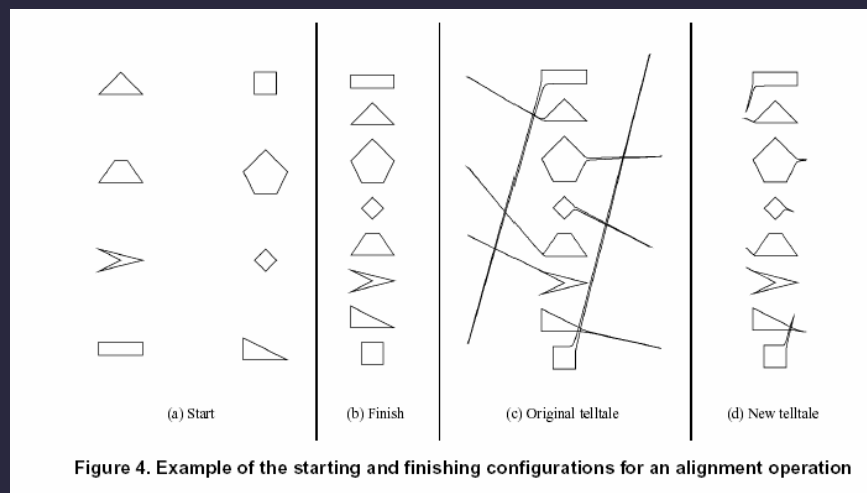
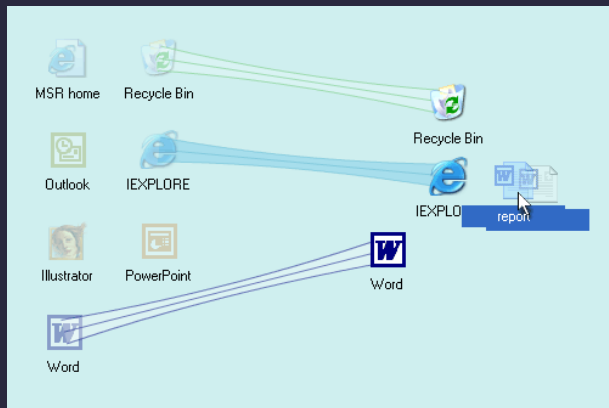


Figure 4. Example of the starting and finishing configurations for an alignment operation

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

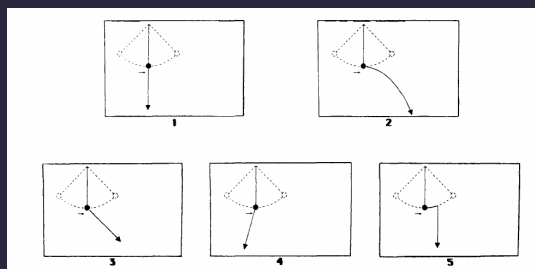
Drag-n-pop [Baudisch 03]



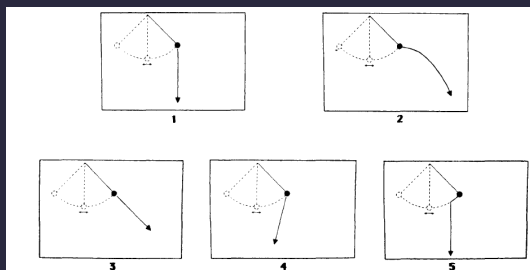
Relevant applications jump to file you are dragging with paths drawn as stretched bands (meant for large screen displays)

What about other transformations (rotation / scale)?

Intuitive physics [Kaiser 92]

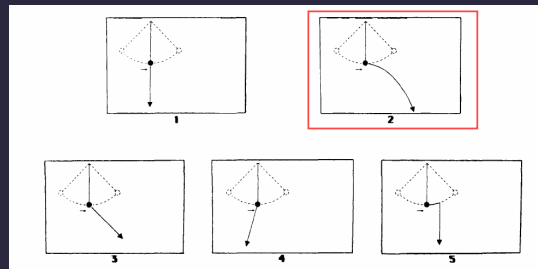


What is motion if string cut at *nadir* of motion?

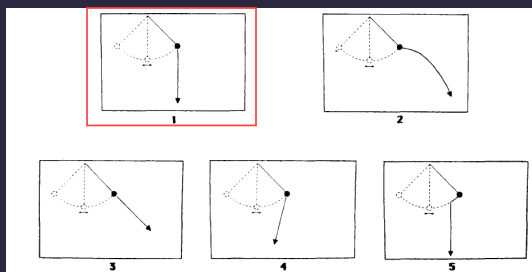


What is motion if string cut at *apex* of motion?

Intuitive physics [Kaiser 92]

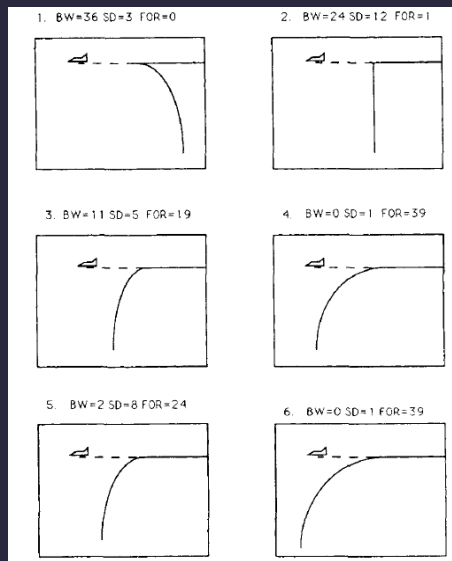


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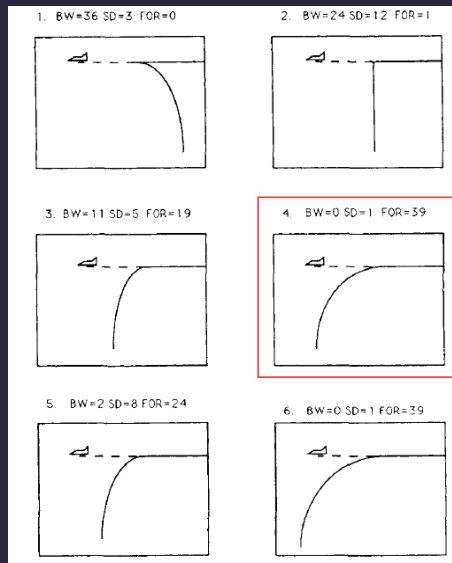


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Intuitive physics [Kaiser 92]



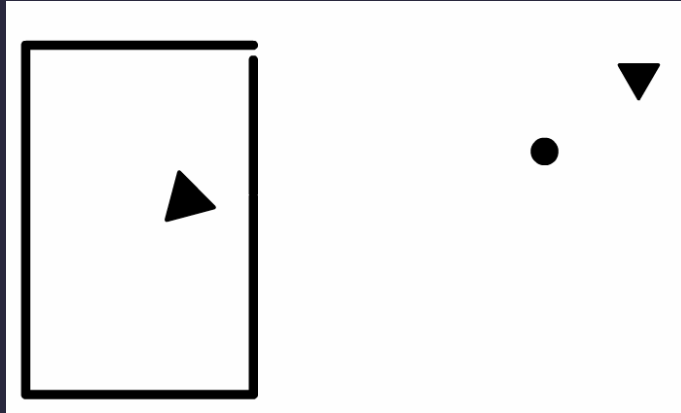
Intuitive physics [Kaiser 92]



Seeing dynamic motion improves performance

Interpreting Animation

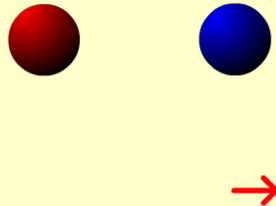
Constructing narratives



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

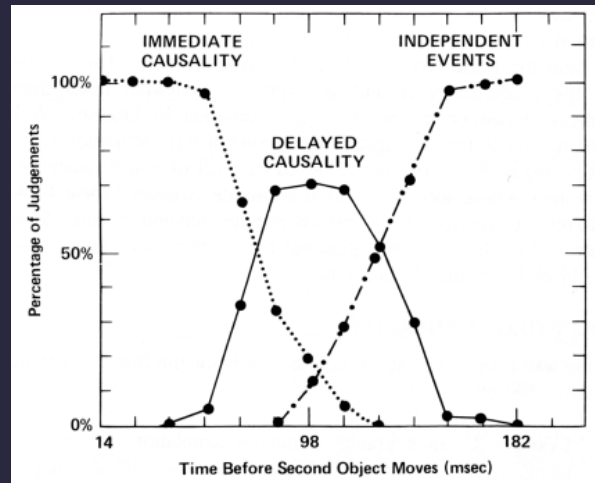
Attribution of causality [Michotte 46]

Michotte demonstration 1. What do you see? Most observers report that "the red ball hit the blue ball." The blue ball moved "because the red ball hit it." Thus, the red ball is perceived to "cause" the blue ball to move, even though the balls are nothing more than color disks on your screen that move according to a programme.



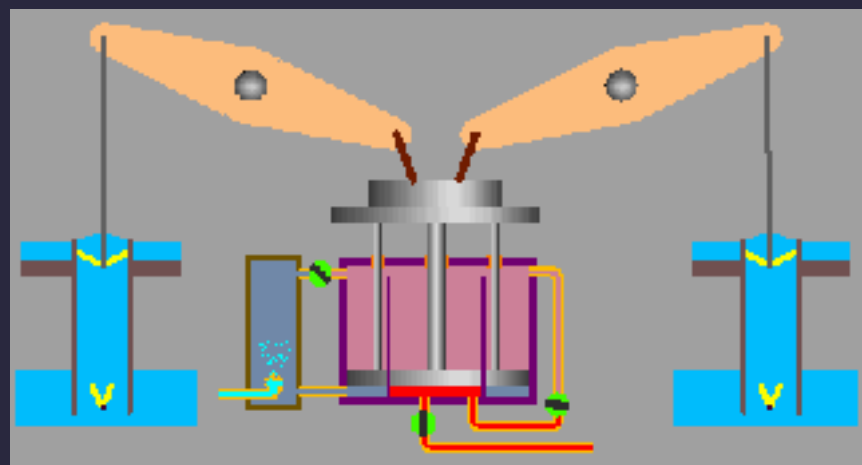
http://cogweb.ucla.edu/Discourse/Narrative/Heider_45.html

Attribution of causality [Michotte 46]

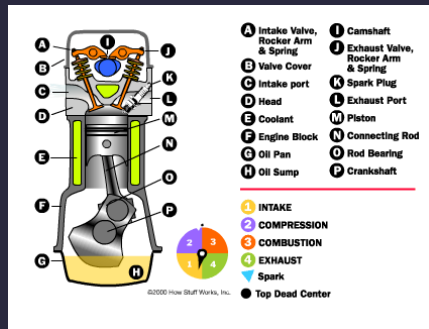


[Reprint from Ware 04]

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?

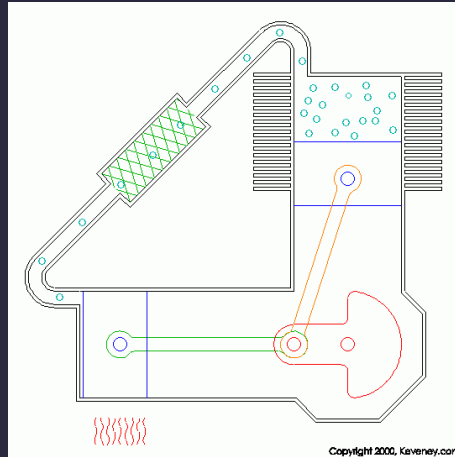
<http://auto.howstuffworks.com/engine1.htm>

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

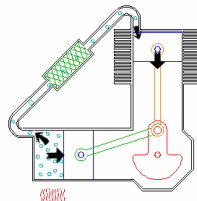


Two-cylinder Stirling engine

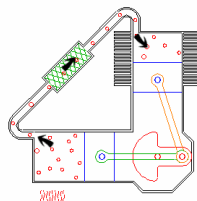
<http://www.keveney.com/Vstirling.html>

Solution I: Break into static steps

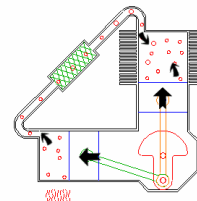
1
Expansion. At this point, most of the gas in the system has just been driven into the hot cylinder. The gas heats and expands driving both pistons inward.



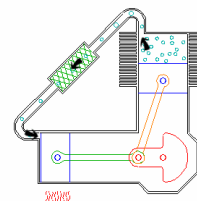
2
Transfer. At this point, the gas has expanded (about 3 times in this example). Most of the gas (about 2/3rd) is still located in the hot cylinder. Flywheel momentum carries the crankshaft the next 90 degrees, transferring the bulk of the gas to the cool cylinder.



3
Contraction. Now the majority of the expanded gas has been shifted to the cool cylinder. It cools and contracts, drawing both pistons outward.



4
Transfer. The now contracted gas is still located in the cool cylinder. Flywheel momentum carries the crank another 90 degrees, transferring the gas back to the hot cylinder to complete the cycle.



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

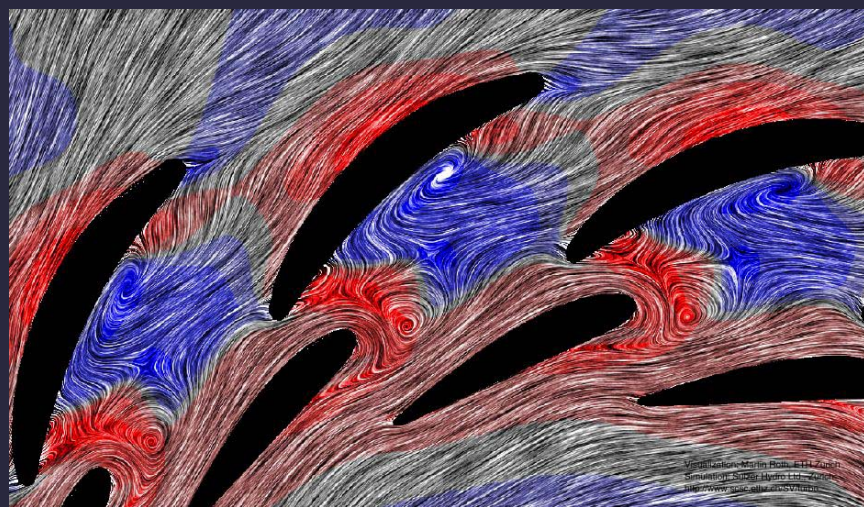
The Value of Visualization



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?

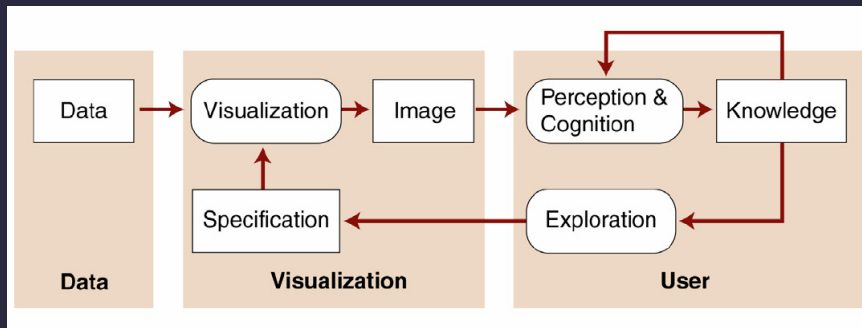
Efficiency

Visualization should use minimal resources

- Not always clear how to measure efficiency

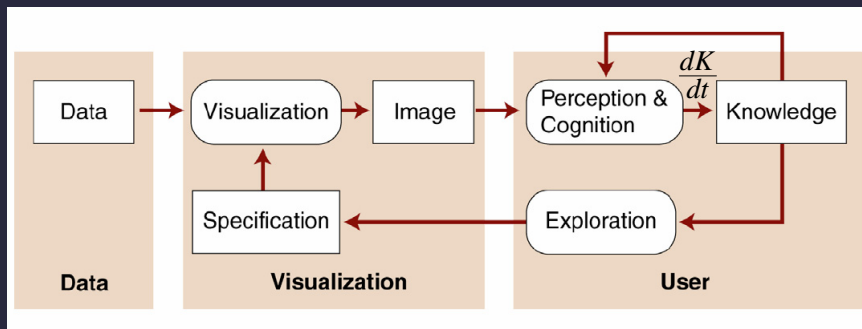
Implication is that visualizations should be judged in the context in which they are used

Generic model



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

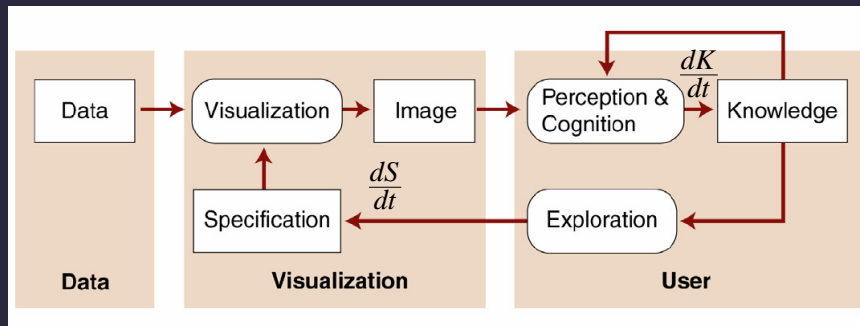
Generic model: Knowledge



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

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

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

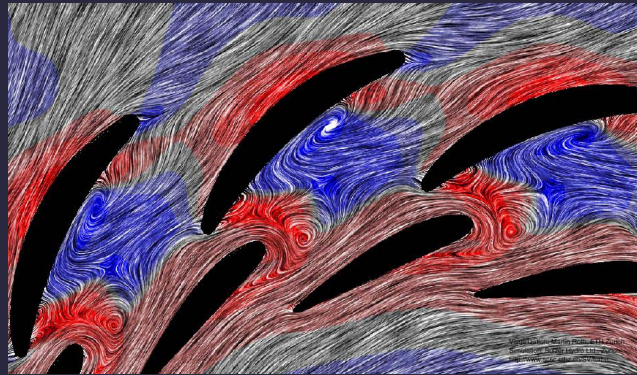
n users; m sessions; k explorative steps

$$\text{Cost} = C_i + nC_u + nmC_s + nmkC_e$$

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

$$\text{Gain} = nmW(\Delta K)$$

Case study: Line integral convolution



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

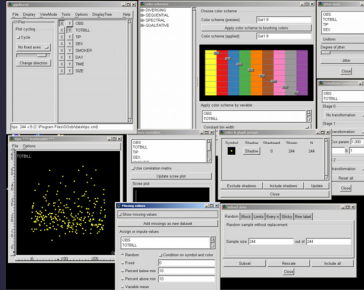
- Visualization may not present most important quantities
- Often user is left to implement visualization technique
- User must learn how to use visualization effectively

Case study: Ggobi

The screenshot shows the Ggobi software interface with several open windows:

- Main Window:** Displays a scatter plot of data points in yellow.
- Choose color scheme:** A window with a color palette and options to apply a color scheme to brushing colors.
- Missing values:** A dialog box for handling missing data, with options like 'Show missing values' and 'Assign or impute values'.
- Subset data:** A dialog box for selecting a subset of data, with options like 'Random', 'Block', 'Limits', 'Every n', 'Sticky', and 'Row label'.
- Other windows:** Several other windows are visible, including 'File', 'Options', and 'DisplayTree', showing the software's menu structure and settings.

Case study: Ggobi



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]



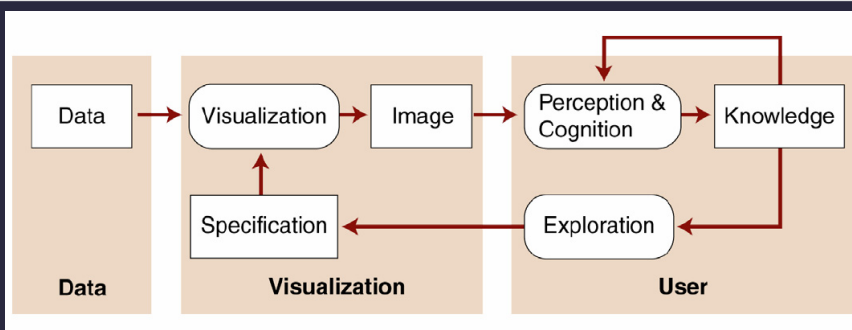
High n

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

Alternative methods scarce (??)

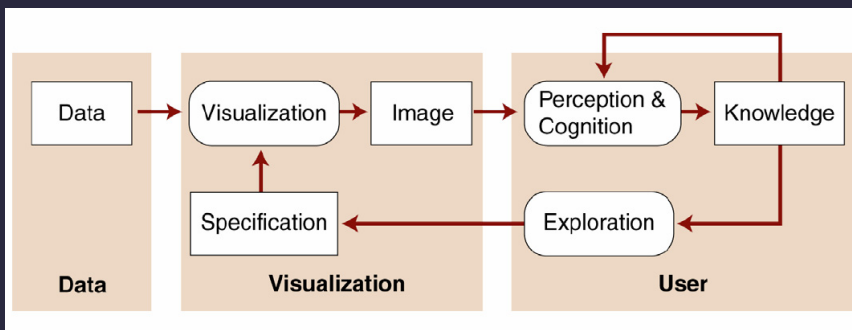
Initial costs low (??)

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?**