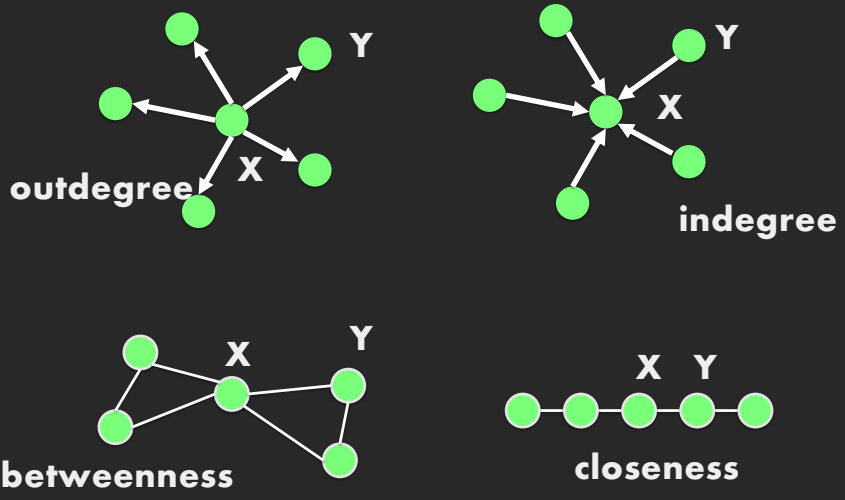
Animation

Maneesh Agrawala

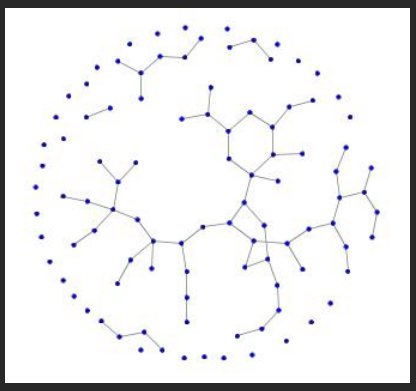
CS 448B: Visualization
Fall 2018

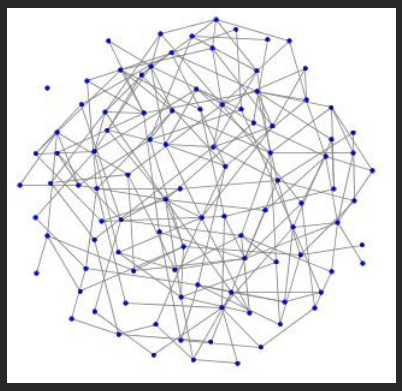
Last Time: Network Analysis

Centrality



How dense is it?





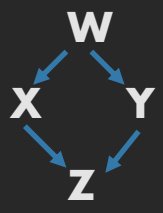
density = e/ e_{max}

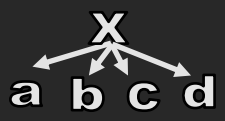
Max. possible edges:

- Directed: $e_{max} = n*(n-1)$
- Undirected: $e_{max} = n*(n-1)/2$

Pattern finding - motifs

Define / search for a particular structure, e.g. complete triads





Announcements

Final project

New visualization research or data analysis

- Pose problem, Implement creative solution
- Design studies/evaluations

Deliverables

- Implementation of solution
- 6-8 page paper in format of conference paper submission
- Project progress presentations

Schedule

- Project proposal: Mon 11/5
- Project progress presentation: 11/12 and 11/14 in class (3-4 min)
- Final poster presentation: 12/5 Location: Lathrop 282
- Final paper: 12/9 11:59pm

Grading

- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

Final poster session

4:20-6pm Wed 12/5 – Lathrop (Library) 282

Provide an overview of your project

- **Problem** - Clear statement of the problem your project addresses
- **Motivation** - Explanation of why problem is interesting and difficult
- **Approach** – Description of techniques or algorithms you
- **Results** - Screenshots and a working demo of the system you built
- **Future Work** – Explanation of how the work could be extended

Bring laptop for demo

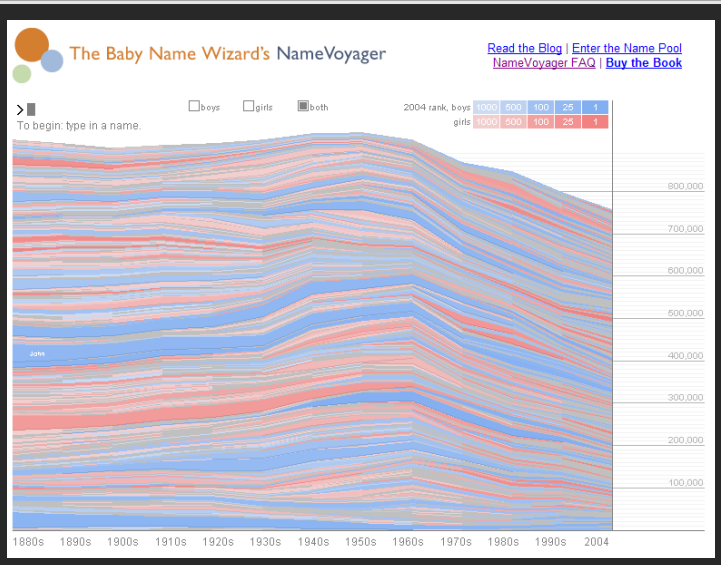
Animation

Question

The goal of visualization is to convey information

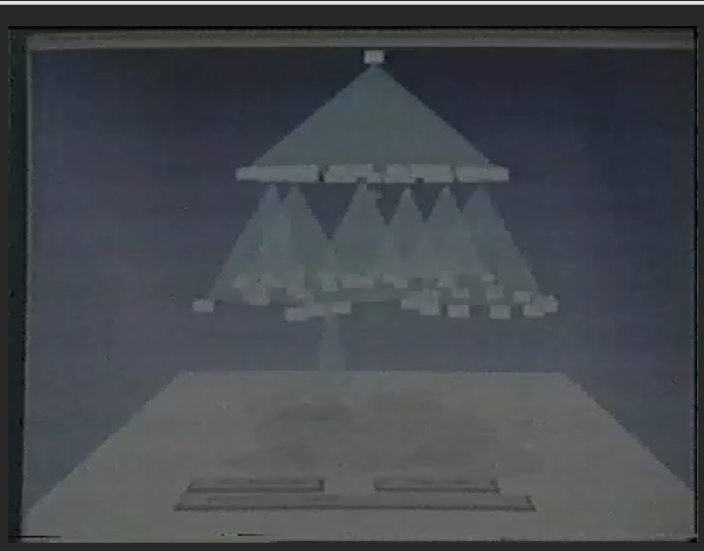
How does *animation* help convey information?

NameVoyager [Wattenberg 04]

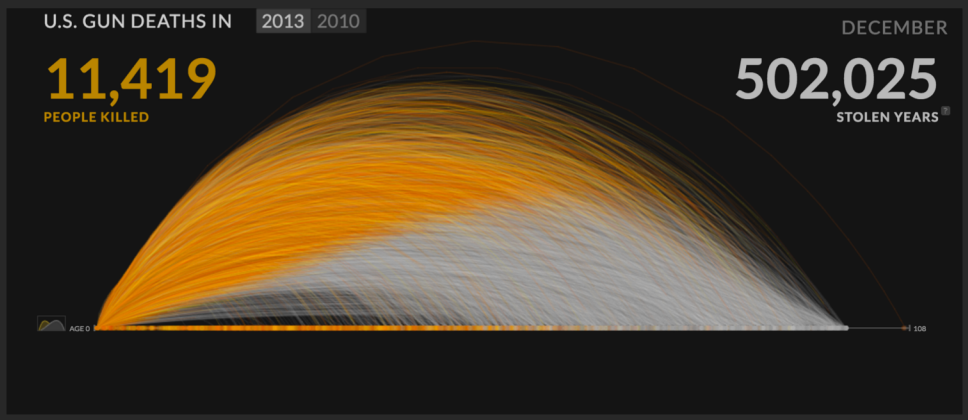


http://www.babynamewizard.com/namevoyager/lnv0105.html

Cone Trees [Robertson 91]

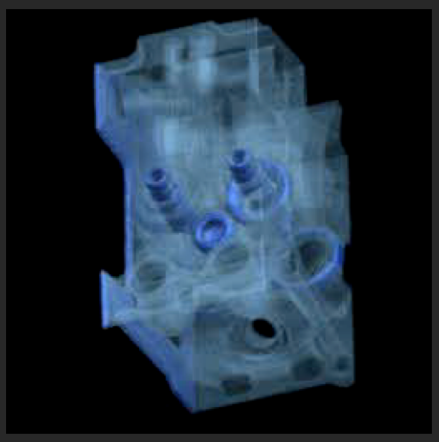


U.S. Gun Deaths [Periscopic 2013]



http://guns.periscopic.com/?year=2013

Volume rendering [Lacroute 95]



Topics

Understanding motion
Interpreting animation
Design principles

Understanding Motion

Motion as a visual cue

Pre-attentive

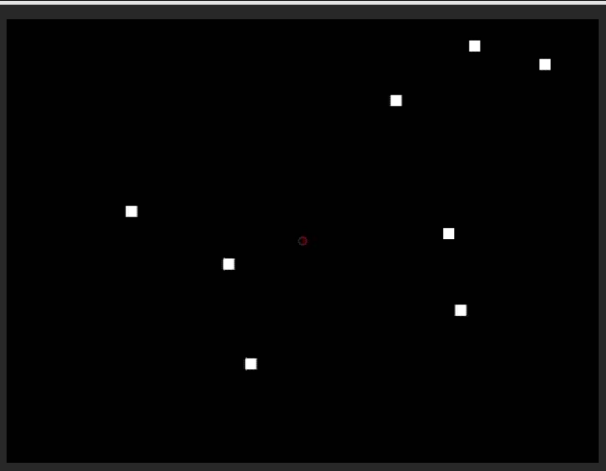
- Stronger than color, shape, …

More sensitive to motion at periphery

Triggers an orientation response

Motion parallax provide 3D cue (like stereopsis)

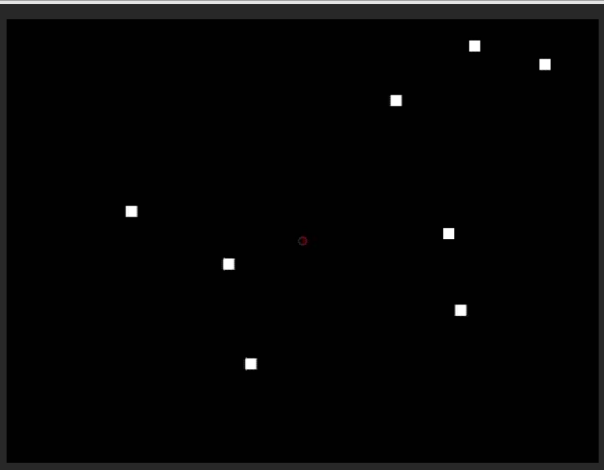
Tracking multiple targets



How many dots can we simultaneously track?

[Yantis 92, Pylyshn 88, Cavanagh 05]

Tracking multiple targets

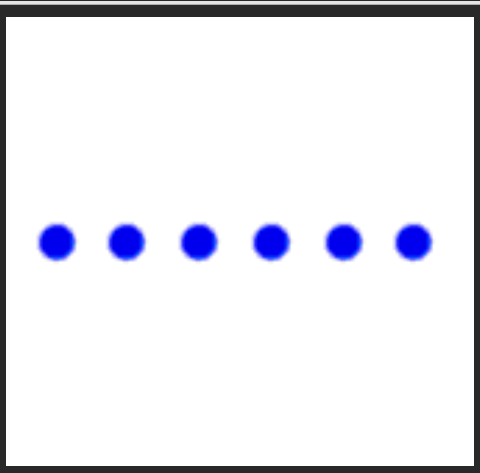


How many dots can we simultaneously track?

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

[Yantis 92, Pylyshn 88, Cavanagh 05]

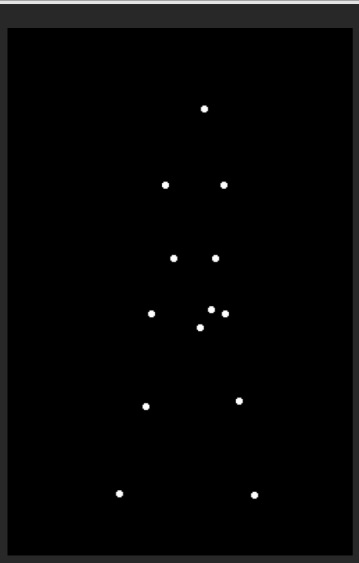
Grouped dots count as 1 object



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/

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 (mostly translations)

end

Motions directly show transitions

Can see change from one state to next

- States are spatial layouts
- Changes are simple transitions (translation, rotation, scale)

Shows transition better, but

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

start **end**

Show motion path in static image

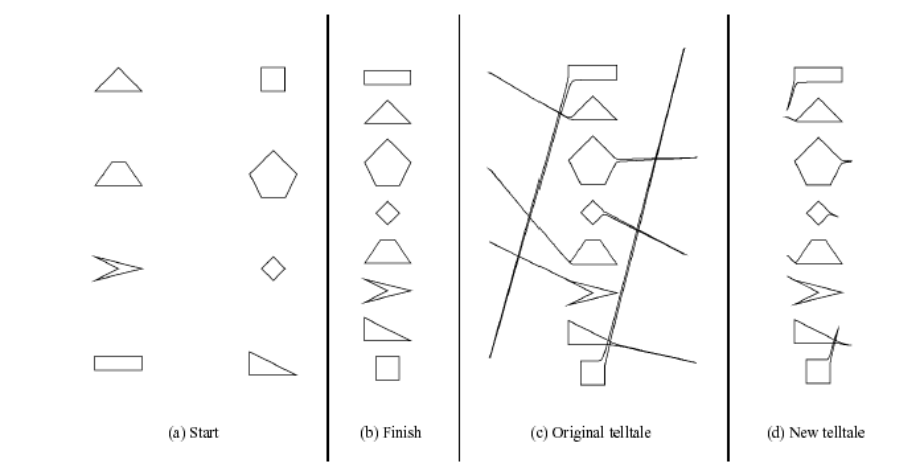
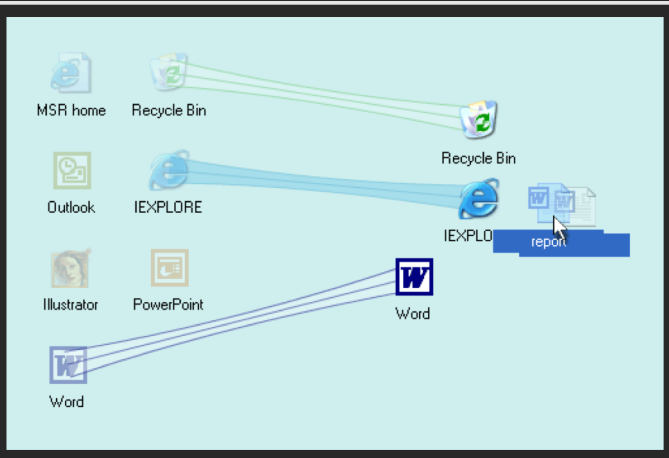


Figure 4. Example of the starting and finishing configurations for an alignment operation

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

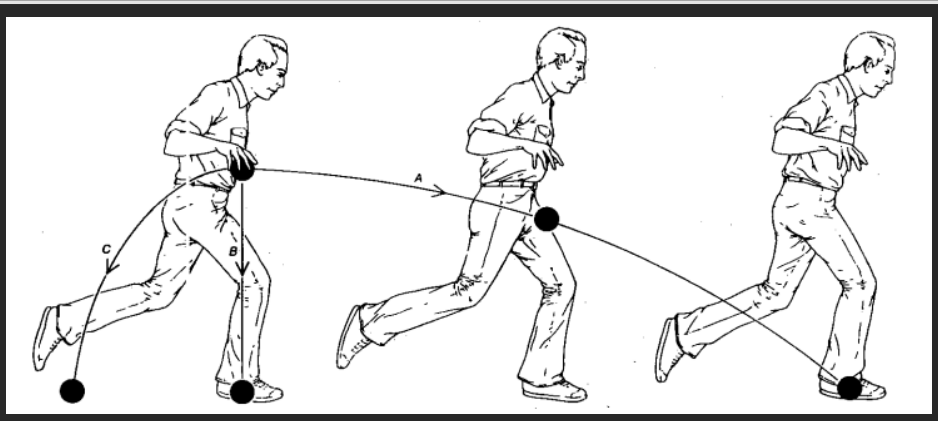
Drag-n-pop [Baudisch 03]



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

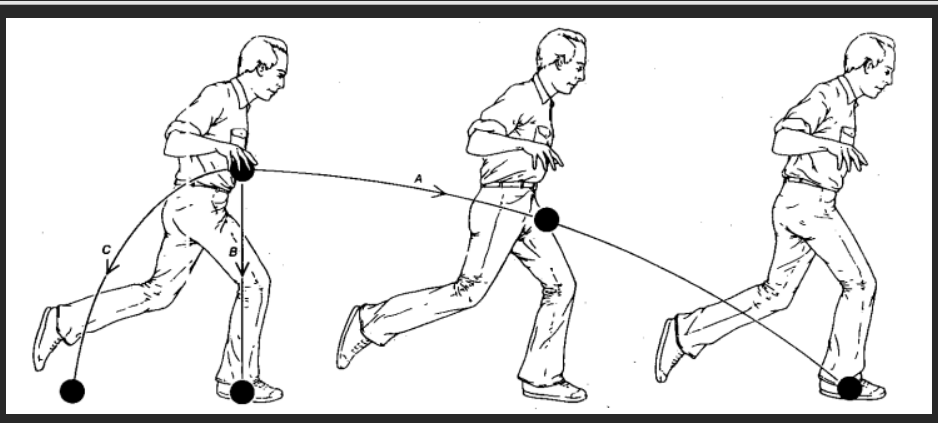
What about other transformations (rotation / scale)?

Intuitive physics [McCloskey 83]



Running man drops ball. What is the trajectory of the ball?

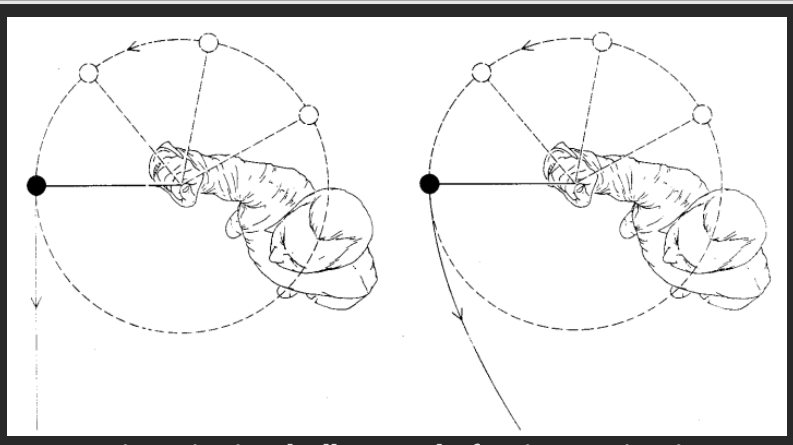
Intuitive physics [McCloskey 83]



Running man drops ball. What is the trajectory of the ball?

College students: Straight down (49%) , Bkwd (6%), Fwd (45%)

Intuitive physics [McCloskey 83]



Man is swinging ball on end of string. String is cut. Draw trajectory of the ball.

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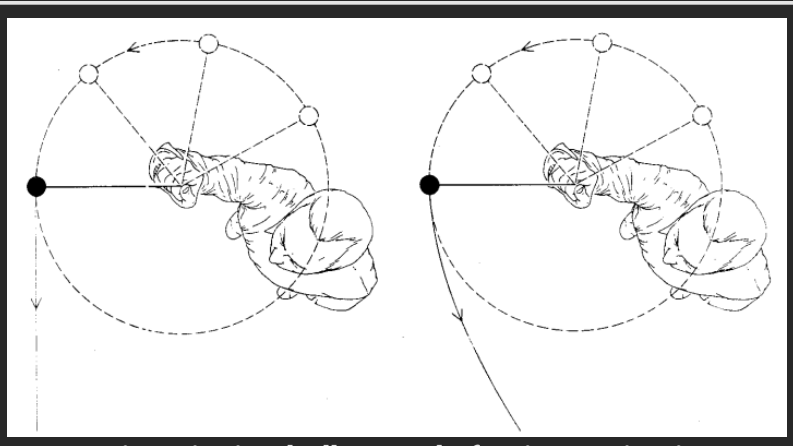
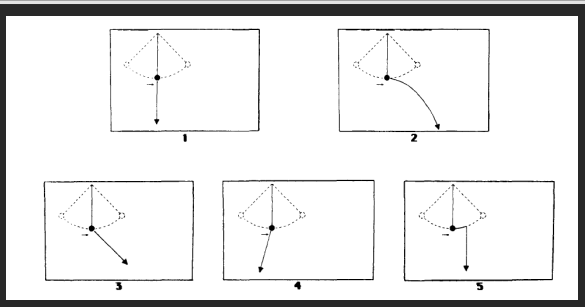


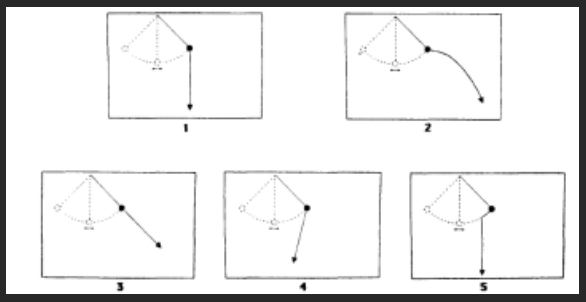
Man is swinging ball on end of string. String is cut. Draw trajectory of the ball.

51% Draw correct path
30% Draw curved path
19% Draw other incorrect paths

Intuitive physics [Kaiser 92]

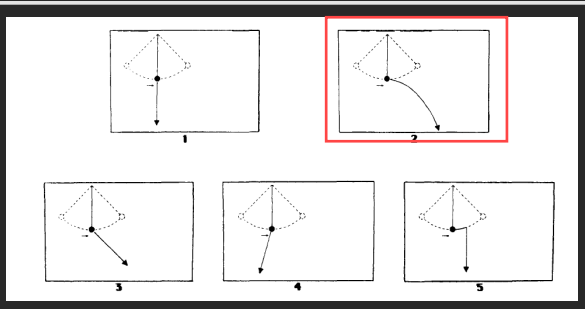


What is motion if string cut at *nadir* of motion?



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

Intuitive physics [Kaiser 92]



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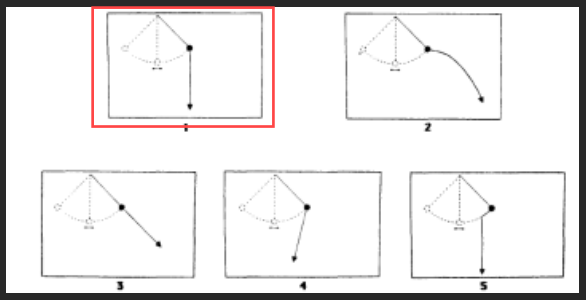
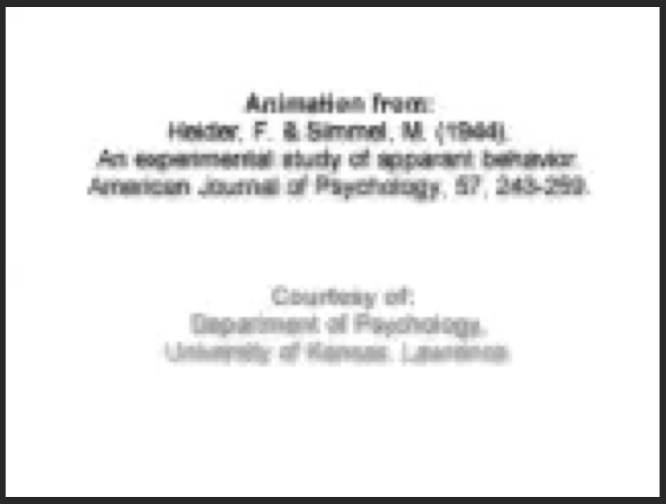


What is motion if string cut at *apex* of motion?

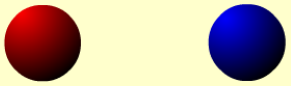
Interpreting Animation

Constructing narratives



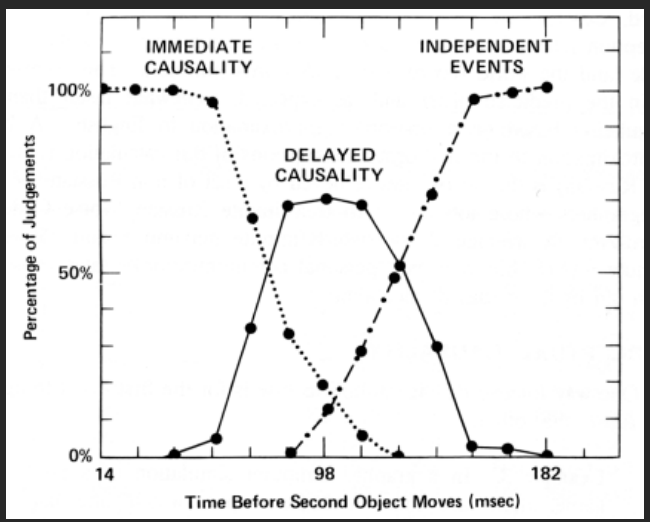
Attribution of causality [Michotte 46]

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.



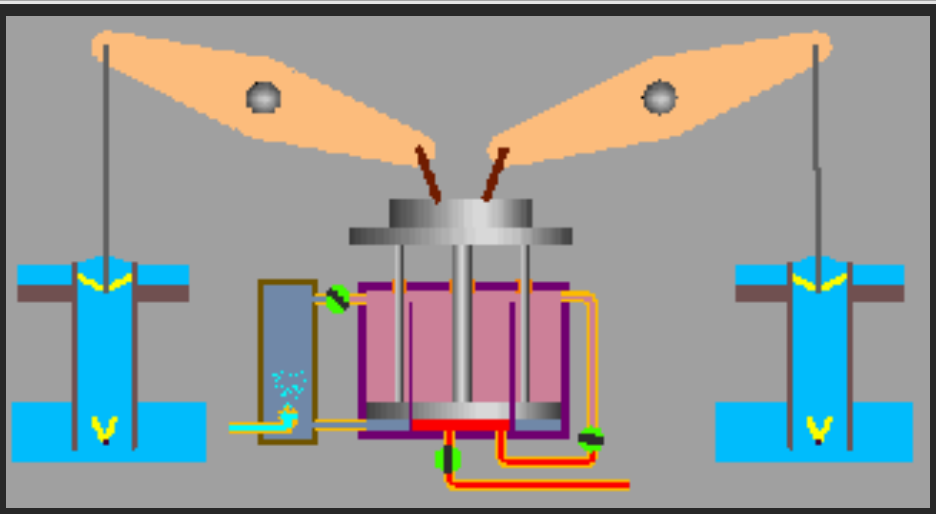
http://cogweb.ucla.edu/Discourse/Narrative/Heider_45.html

Attribution of causality [Michotte 46]



[Reprint from Ware 04]

How does it work?

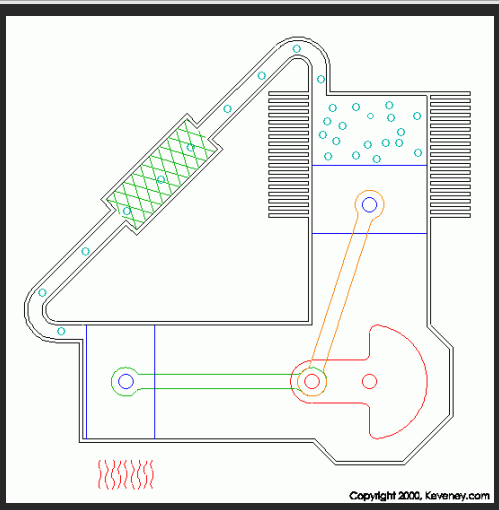


Problems [Tversky 02]

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

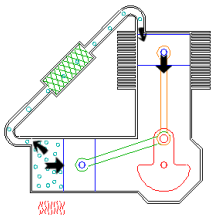


Two-cylinder Stirling engine
http://www.keveney.com/Vstirling.html

Solution I: Break into static steps

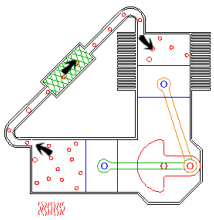
1

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.



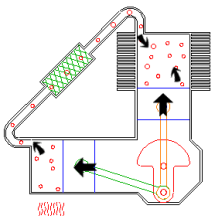
2

Transfer. At this point, the gas has expanded (about 3 times in this example). Most of the gas (about 2/3rds) 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.



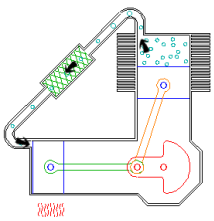
3

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 to 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?
- 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

Design Principles for Animation

Principles for conveying information

Congruence:

The structure and content of the external representation should correspond to the desired structure and content of the internal representation.

Apprehension:

The structure and content of the external representation should be readily and accurately perceived and comprehended.

[from Tversky 02]

Principles for Animation

Congruence

- Maintain valid data graphics during transitions
- Use consistent syntactic/semantic mappings
- Respect semantic correspondence
- Avoid ambiguity

Apprehension

- Group similar transitions
- Minimize occlusion
- Maximize predictability
- Use simple transitions
- Use staging for complex transitions
- Make transitions as long as needed, but no longer

Animated Transitions in Statistical Data Graphics

Jeffrey Heer
George G. Robertson

Microsoft Research

Summary

Animations convey motion, action, story, process

Problems

- Divided attention
- Transient

Techniques

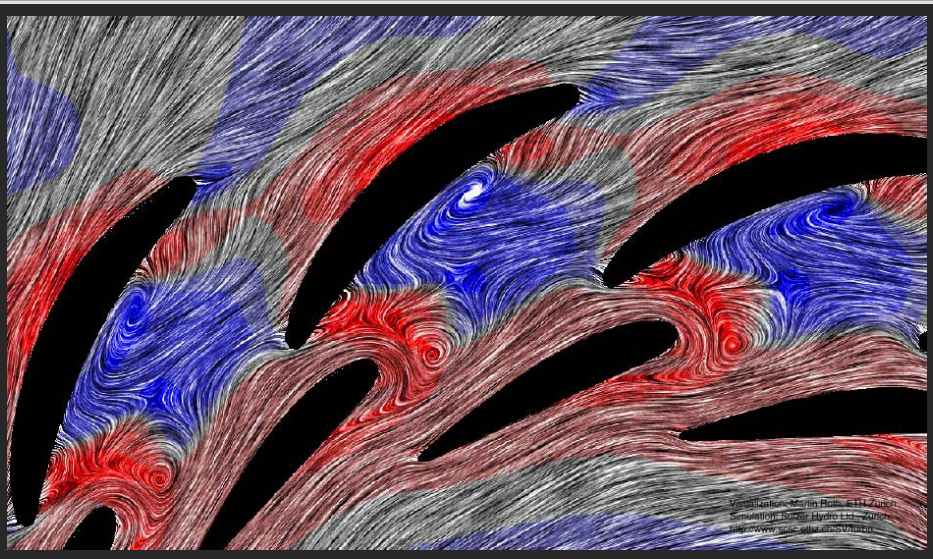
- Aid segmentation into events, actions, sequences, story
- Relies on our ability to fill in temporal gaps (closure)
- More research required on principles for creating effective animated visualizations

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?

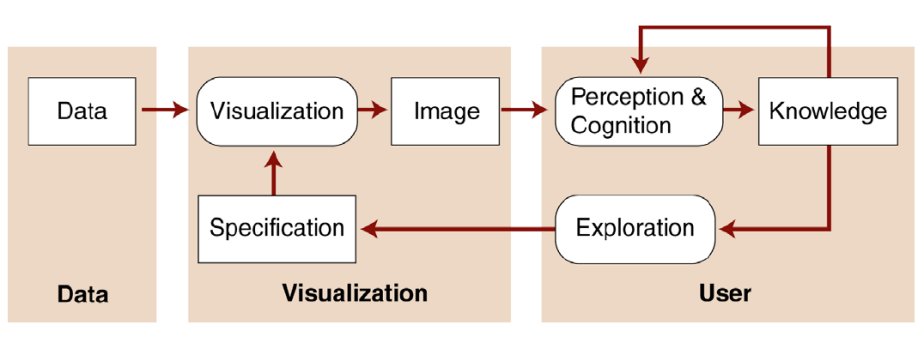
Efficiency

Visualization should use minimal resources

- Not always clear how to measure efficiency

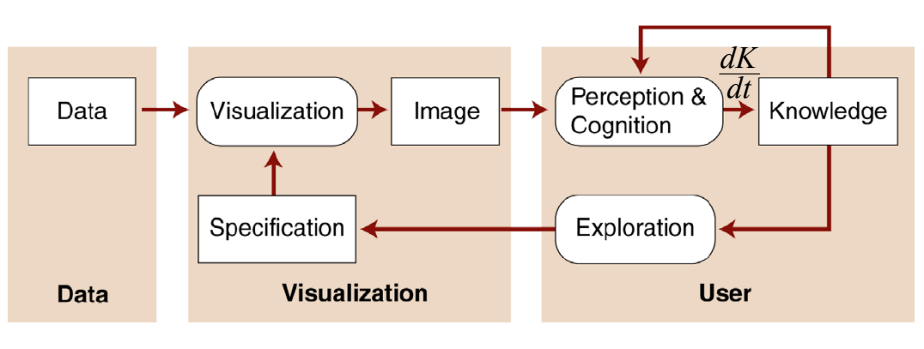
Implication is that visualizations should be judged in the context in which they are used

Generic model



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

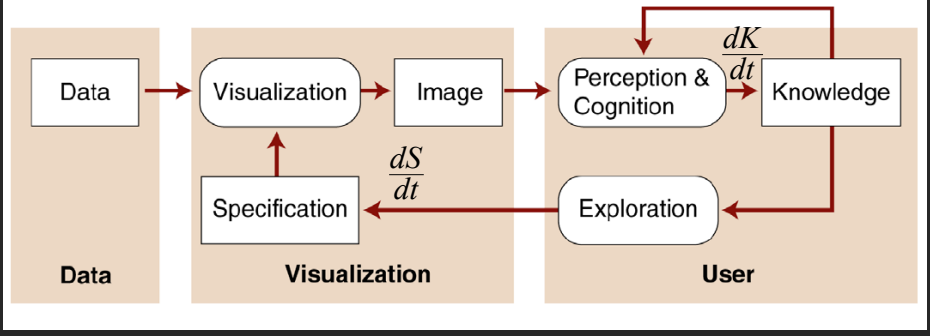
Generic model: Knowledge



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

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

Generic model: Specification



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

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

Economic model

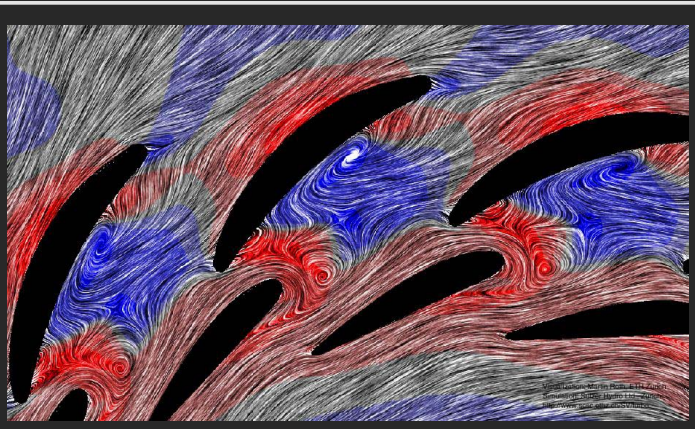
C_i: Initial development costs
C_u: Initial costs per user
C_s: Initial costs per session
C_e: Perception and exploration costs

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

$Cost = C_i + nC_u + nmC_s + nmkC_e$

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

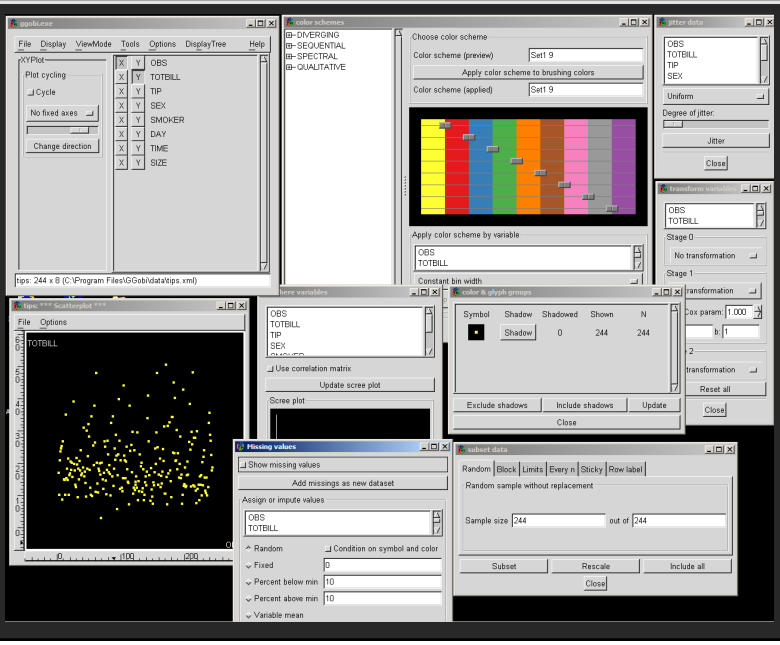
Case study: Line integral convolution



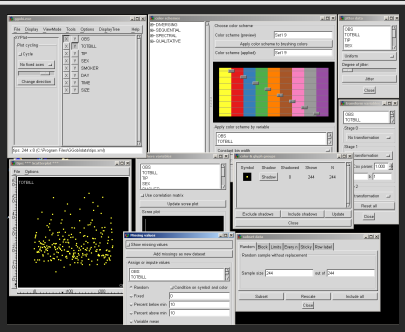
High initial costs C_u, low *n*, low *m*, very high K_0, ΔK unclear

- 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



Case study: Ggobi



Interface is hard to learn

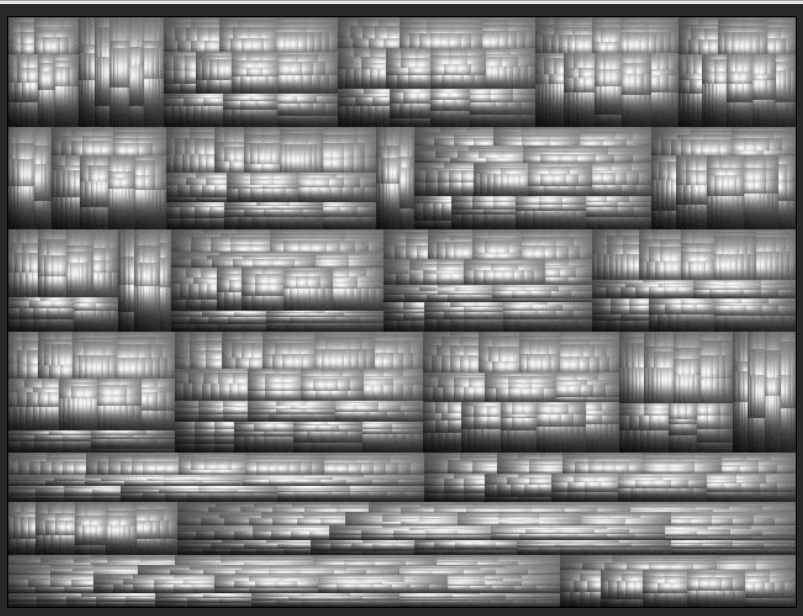
Specification process is subjective

- 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]



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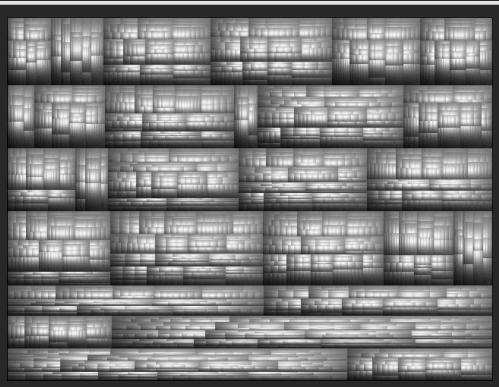
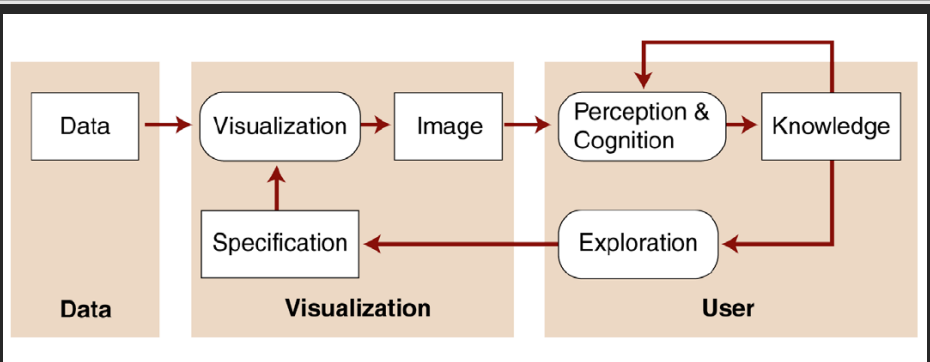


High n
Low m (several times a year) – not negligible (??)
Alternative methods scarce (??)
Initial costs low (??)

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?