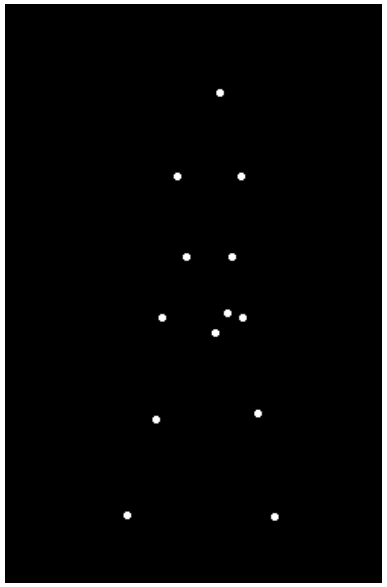


IAT 814
Knowledge Visualization

Animation

Lyn Bartram

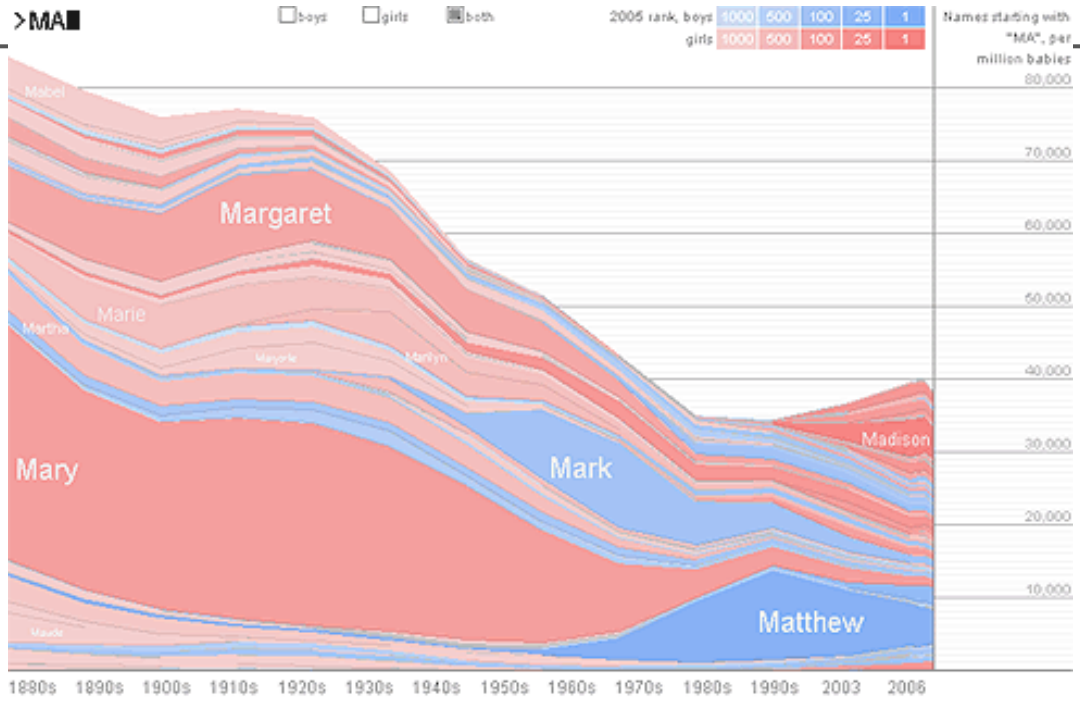
SFU

SCHOOL OF INTERACTIVE ARTS + TECHNOLOGY

We Use Animation to…

- Show change over time
- Add dimension to 2D space
- Visual variable to encode data
- draw attention
- Illustrate system dynamics
- Guide a user through transitions in views
  - Improve data navigation
- Delight and engage
  - Tell stories / scenarios: cartoons
  - Create a character / an agent

Example: Name Voyager



http://www.babynamewizard.com/voyager

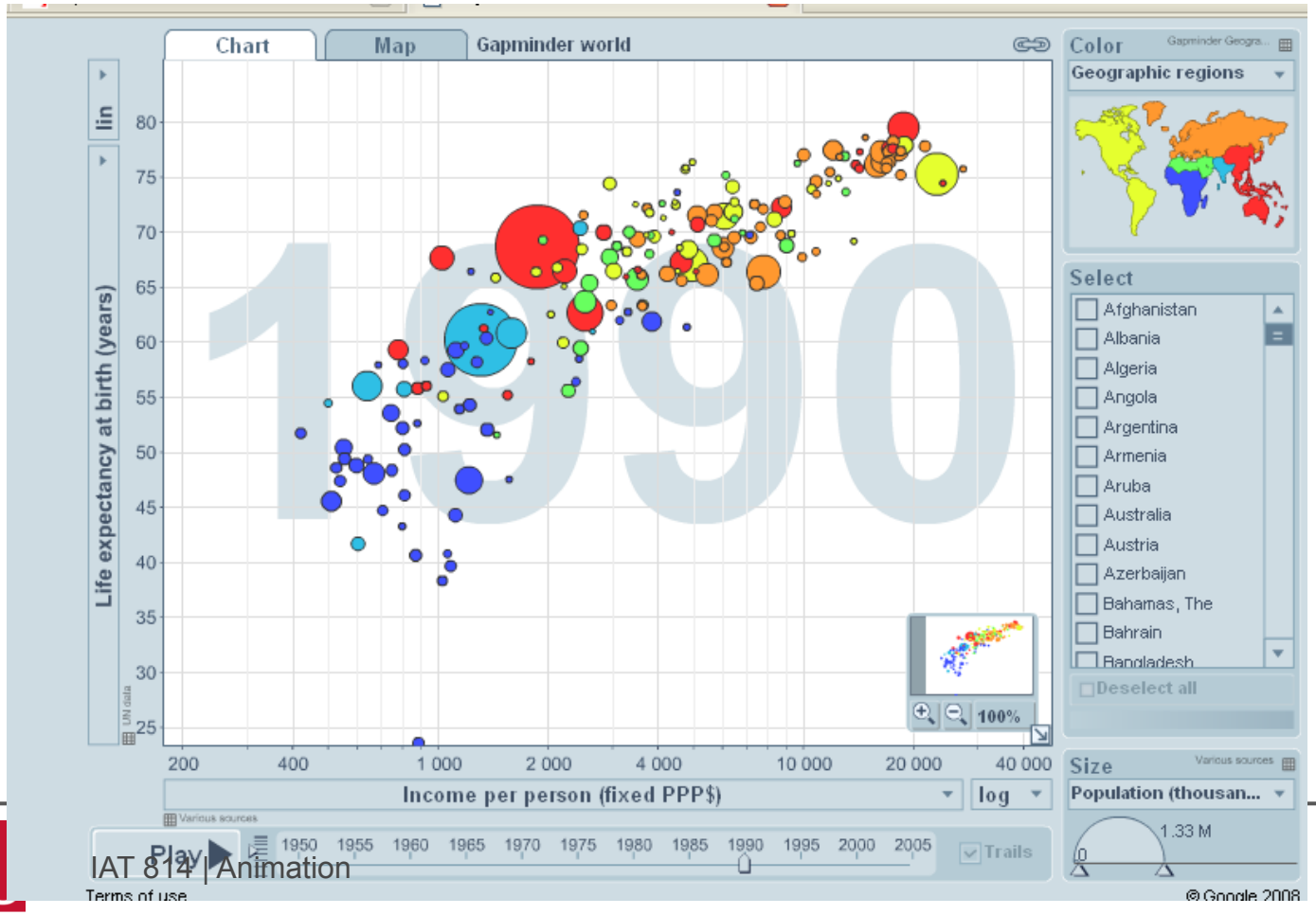
Wattenberg, Martin. "Baby names, visualization, and social data analysis." Information Visualization, 2005. INFOVIS 2005. IEEE Symposium on. IEEE, 2005.

Example: Gap Minder

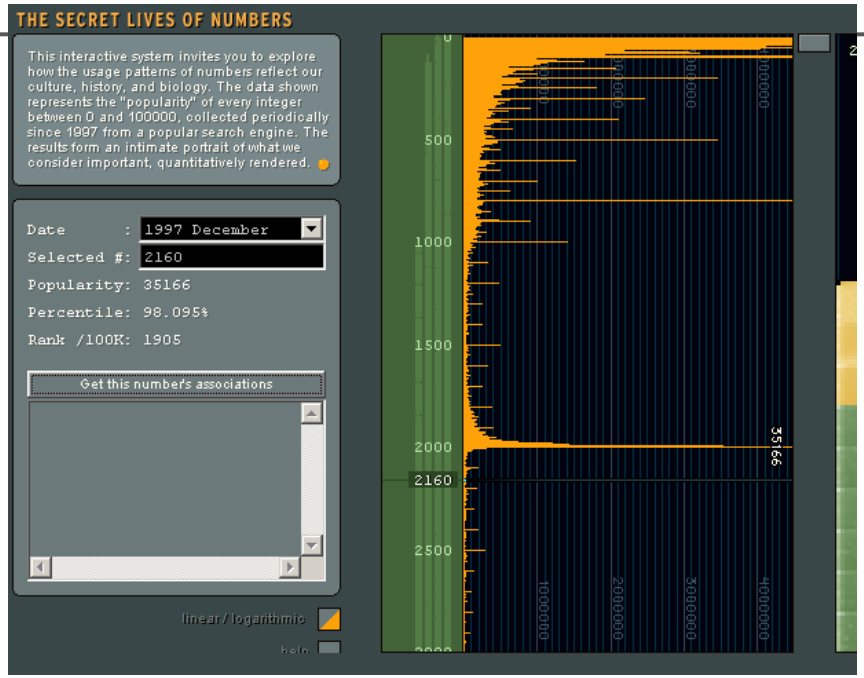
Animating scatter plots, and linking them to a story

http://www.gapminder.org/

http://www.gapminder.org/world/



Animation + Interactivity



Secret Lives of Numbers by Golan Levin

- http://www.turbulence.org/Works/nums/applet.html

Motion perception

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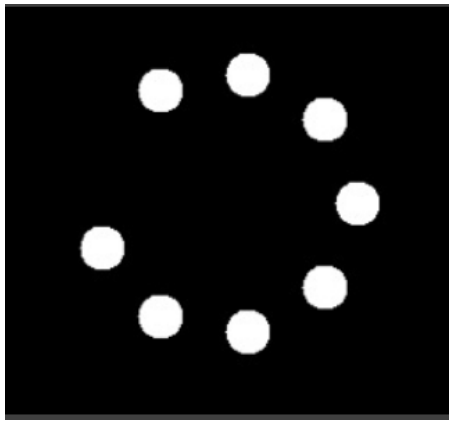
Animation into motion?

- When does a sequence of static images (frames) become perceived as motion?

- Smooth motion can be perceived at ~10 frames/second
  - 100 ms
  - 10 Hz
- Flicker can be perceived at 60 Hz

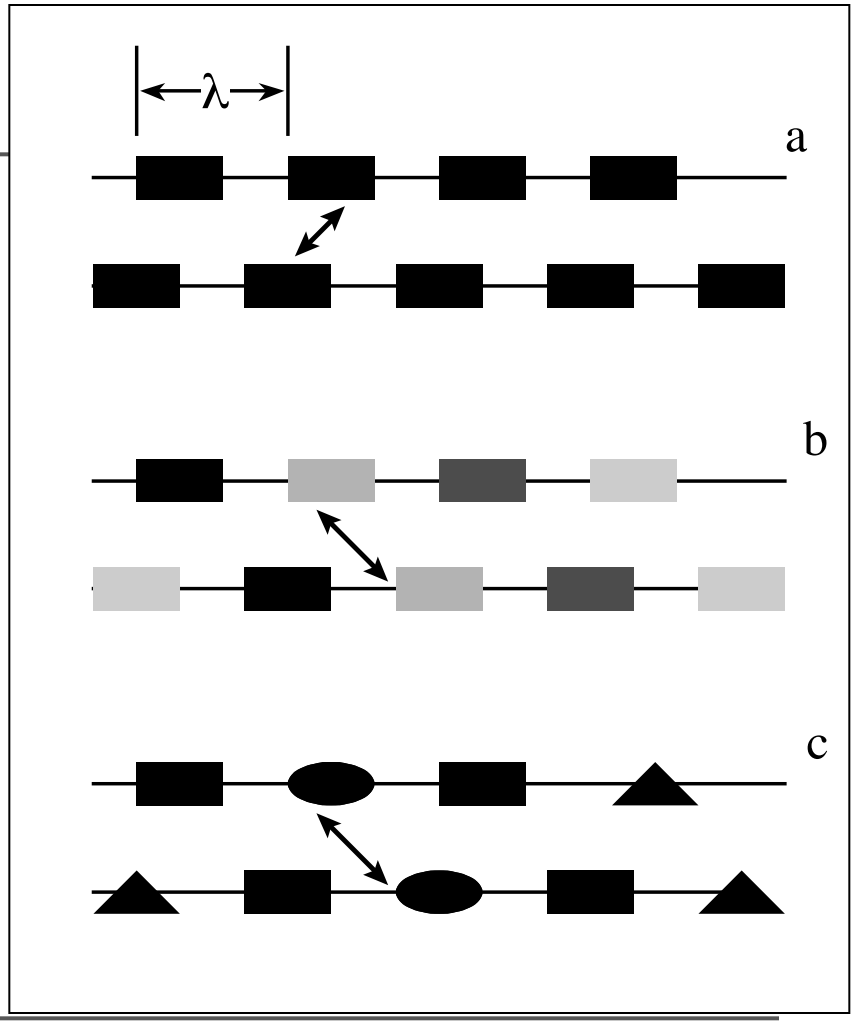
- Film is 24 Hz



http://www1.psych.purdue.edu/Magniphi/PhiIsNotBeta/phi2.html

Limitation due to Frame Rate

- Can only show motions that are limited by the Frame Rate.
- Maximum displacement of λ/2 before perception of reversed direction
- λ is aperture size
- We can increase by using additional symbols.
- Limitation on throughput related to *correspondence problem*



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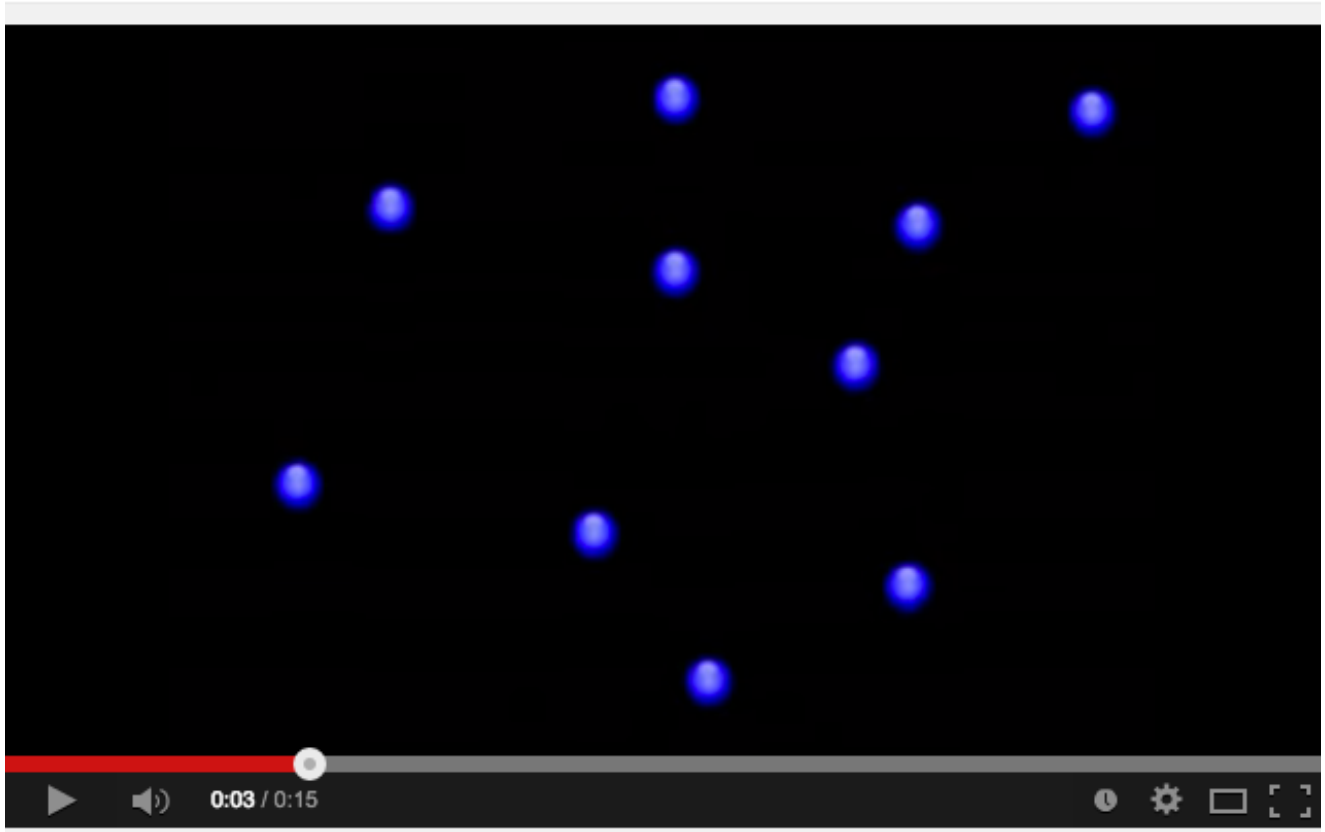
Motion is our widest visual cue

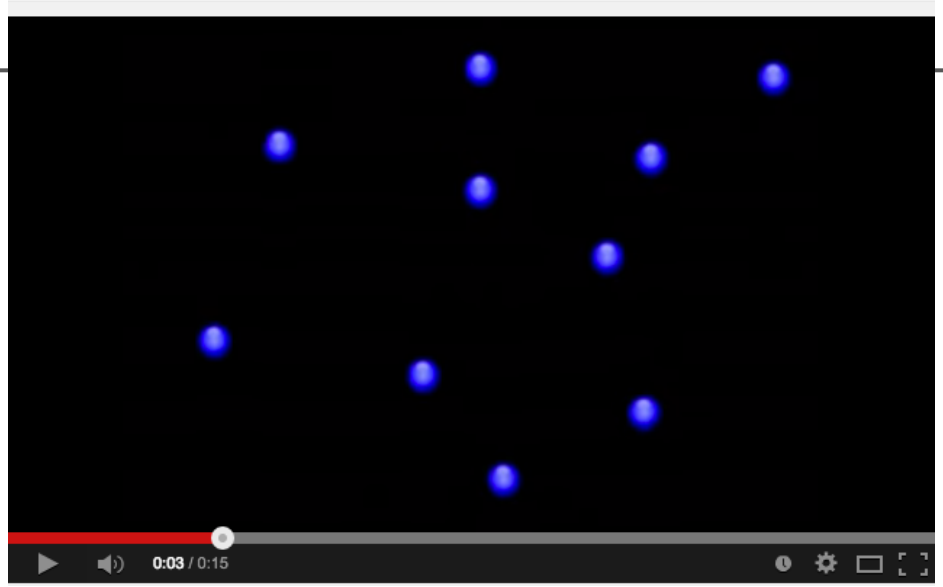
- Pre-attentive, stronger than color, shape, …
- More sensitive to motion at periphery than anything else
- Motion parallax provides 3D cue (like stereopsis)

- Similar motions perceived as a group

We can track multiple objects



Multiple object tracking (FINSTs)

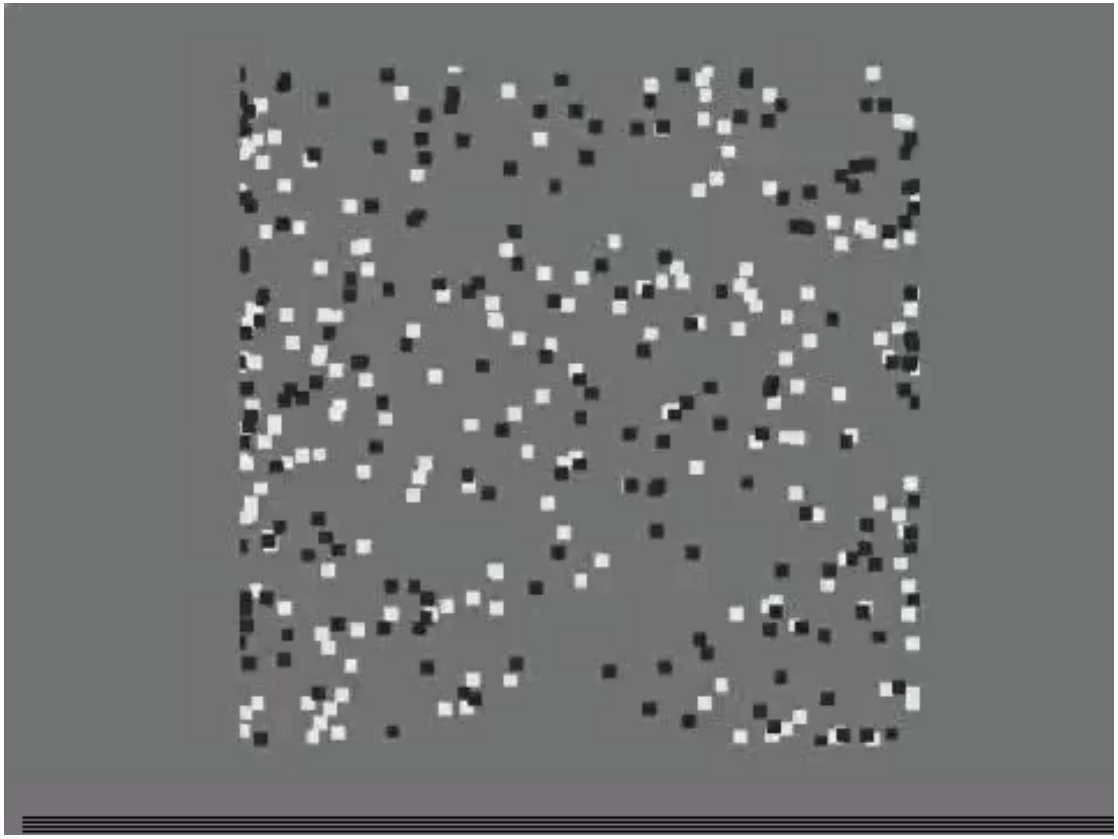


We can track ~4-6 objects simultaneously

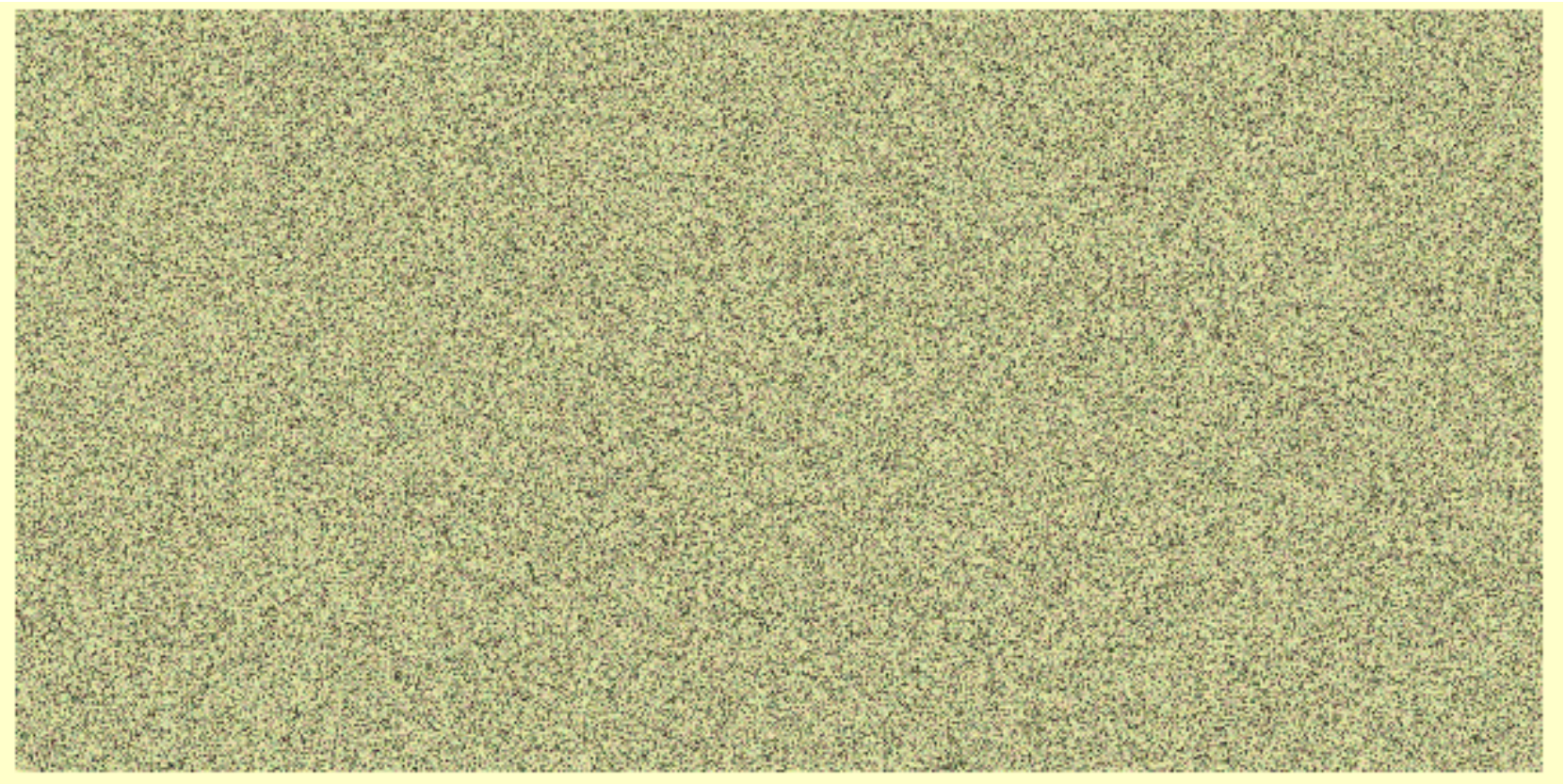
- 6 with training
- >6 difficulty increases significantly

- *Yantis, S. (1992). Multielement visual tracking: Attention and perceptual organization. Cognitive Psychology, 24, 295-340*
- *Pylyshyn, Z. W. (2001). Visual indexes, preconceptual objects, and situated vision. Cognition, 80, 127-158*

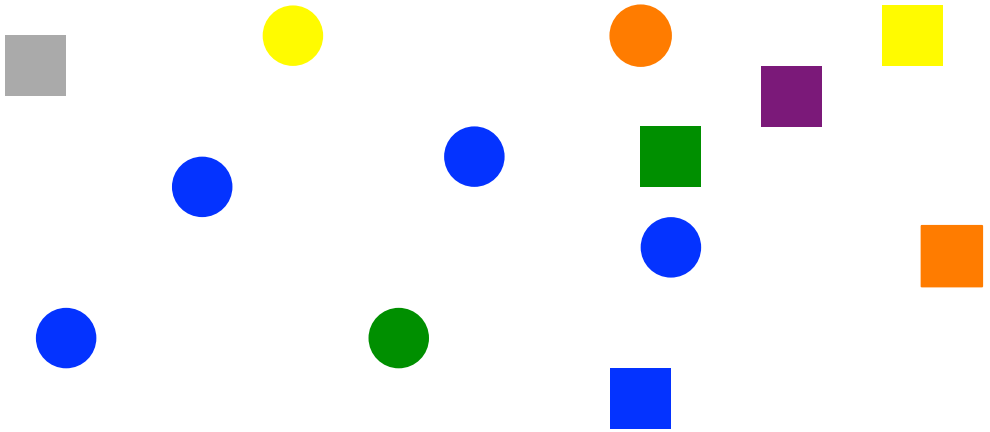
We derive structure from motion



We segment by common fate

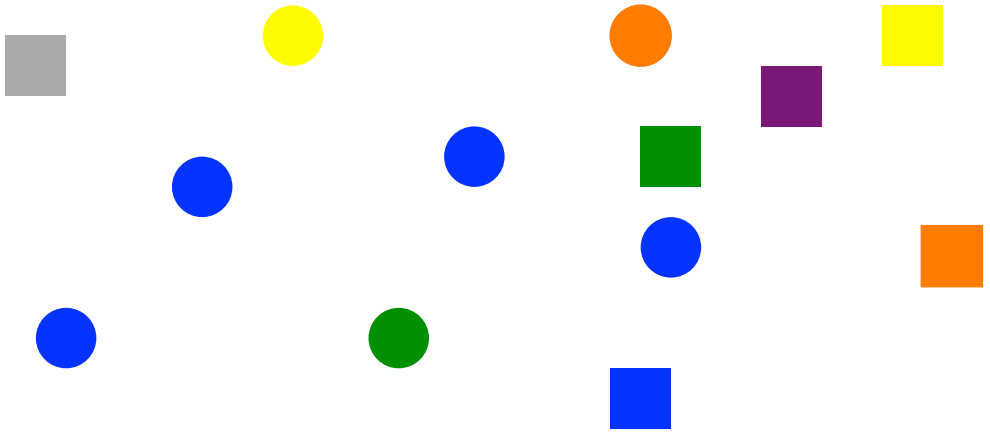


Objects moving in similar ways are seen as a group



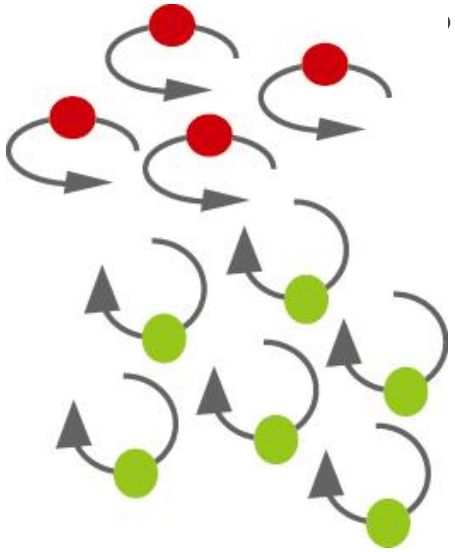
L. Bartram and C. Ware. Filtering and Brushing with Motion, Information Visualization 1(1), 2002.

We differentiate moving groups (fields)



L. Bartram and C. Ware. Filtering and Brushing with Motion, Information Visualization 1(1), 2002.

Motion as a visual attribute

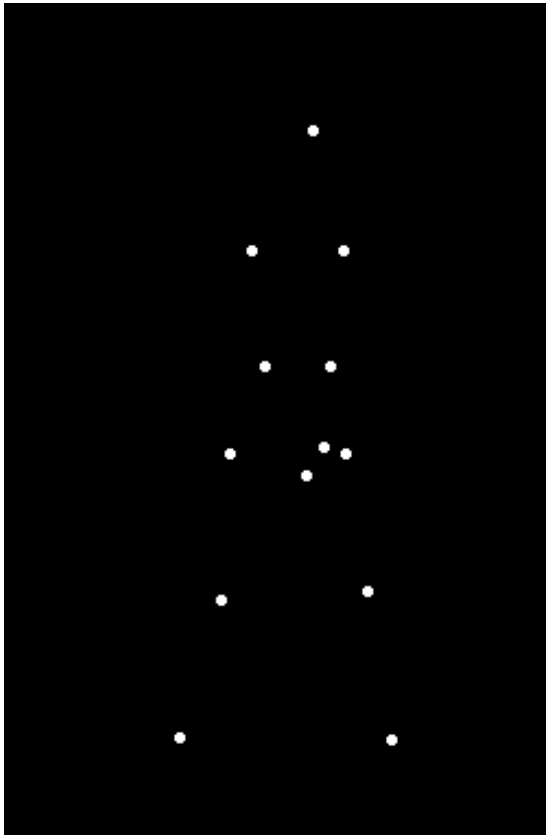


- correlation between points:
  - frequency, phase or amplitude
  - Result: phase is most noticeable (Ware)
  - Shape is also a strong grouper (Bartram)

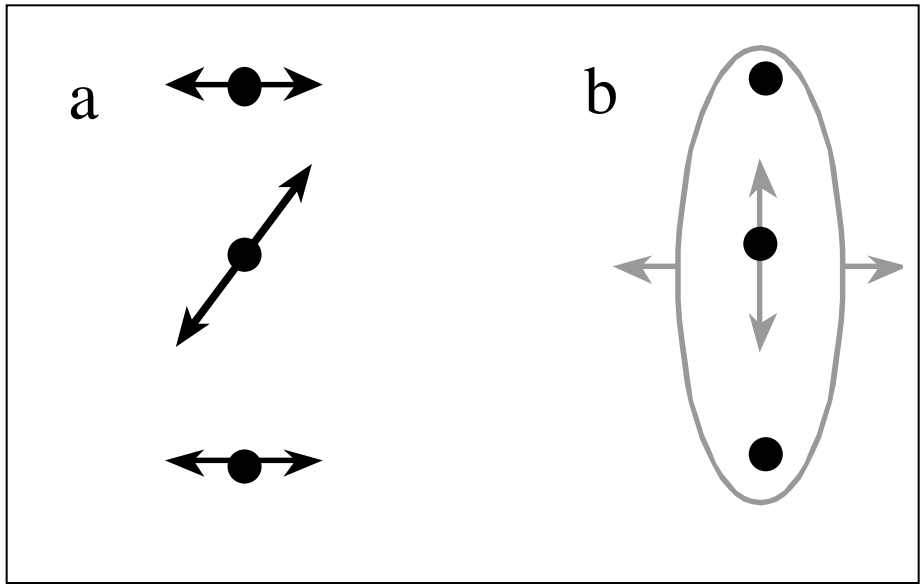
These slides are largely copied from Colin Ware, Perception for Design
http://ccom.unh.edu/vislab/VisCourse/index.html © 2006

We connect the dots with biological motion

Johansson, Gunnar. "Visual perception of biological motion and a model for its analysis." Perception & psychophysics 14.2 (1973): 201-211.



Motion is Highly Contextual



- Group moving objects in hierarchical fashion.

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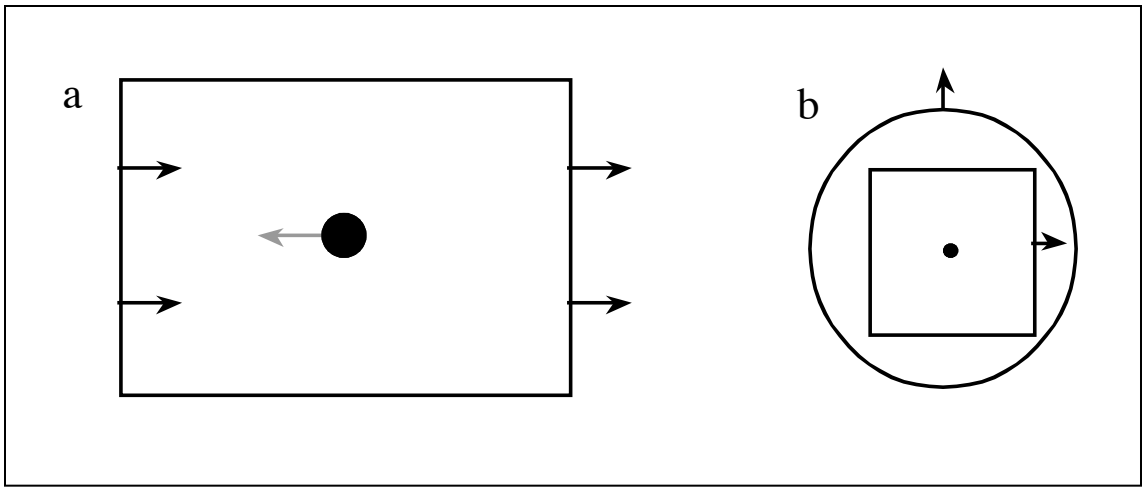
http://ccom.unh.edu/vislab/VisCourse/index.html © 2006

Frame as motion context

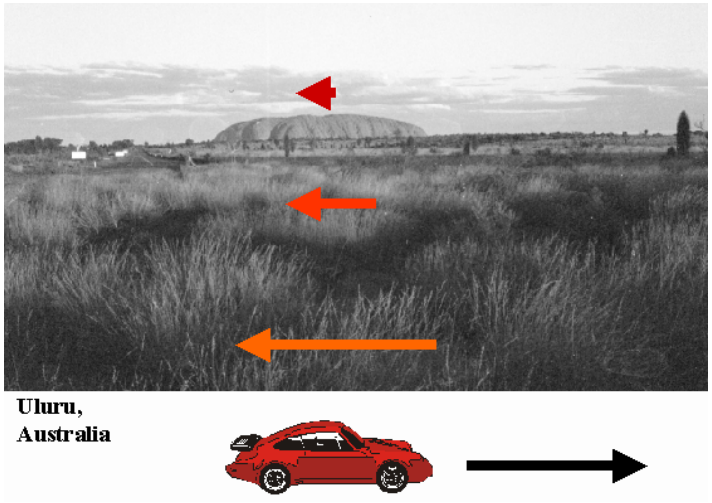
- The stationary Dot is perceived as moving in (a).
  - *Vection (*Riecke*)*
- The circle has no effect on this process in (b).

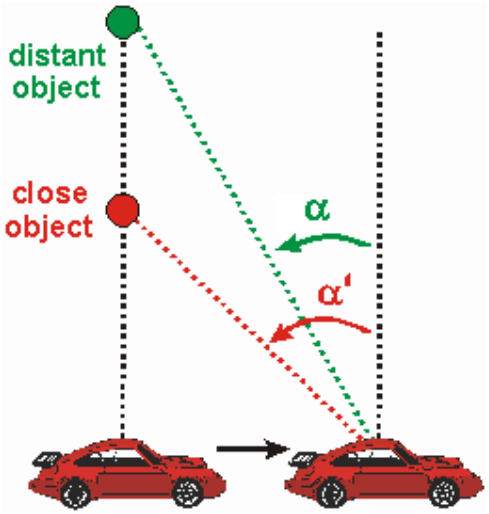


These slides are largely copied from Colin Ware, Perception for Design
http://ccom.unh.edu/vislab/VisCourse/index.html © 2006

Motion parallax

- when you look out of the side window of a car or a train, you see close objects translating very fast (bushes) and distant objects passing very slow (mountains) or even being stationary (sun)
- *Motion parallax*: the inverse relation between angular speed and distance





Motion parallax

- Demo1: http://psych.hanover.edu/Krantz/MotionParallax/MotionParallax.html

- Demo 2 http://www.psypress.co.uk/mather/resources/swf/Demo10_2.swf

Motion in Visualization

Change over time

Potential uses?

- *Data:* map basic properties onto values (Huber+Healey)
  - Phase
  - Flicker
  - velocity
- *Metadata*:
  - Uncertainty (Alex Pang)
  - Set types (grouping and linking)

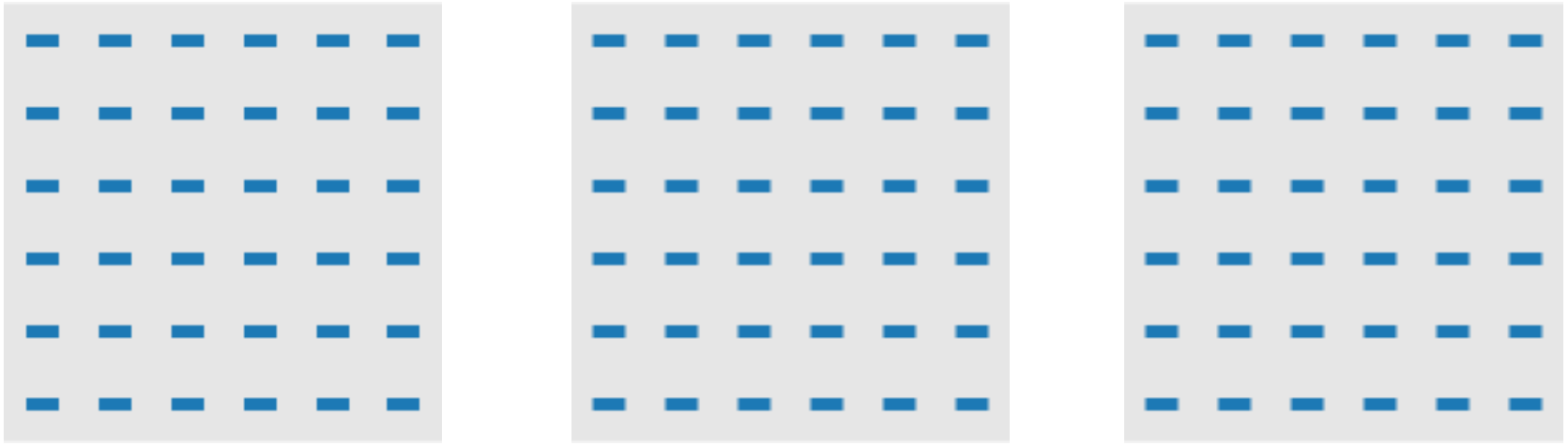
- *Relations*: causality (Ware,Bartram)

Potential uses?

- *Emphasis*: cognitive tools for managing attention
  - events (external dynamic information)
  - markers (navigation, history, guides)
- *Grouping and Separating*:
  - linking heterogeneous, scattered elements (brushing)
  - filtering in context
- *Affect*: meaning, impressions, emotion, “a sense of”

Motion for coding data

- Simple motion properties for encoding data values



Flicker Direction Velocity

Huber, Daniel E., and Christopher G. Healey. "Visualizing data with motion." Visualization, 2005. VIS 05. IEEE. IEEE, 2005.

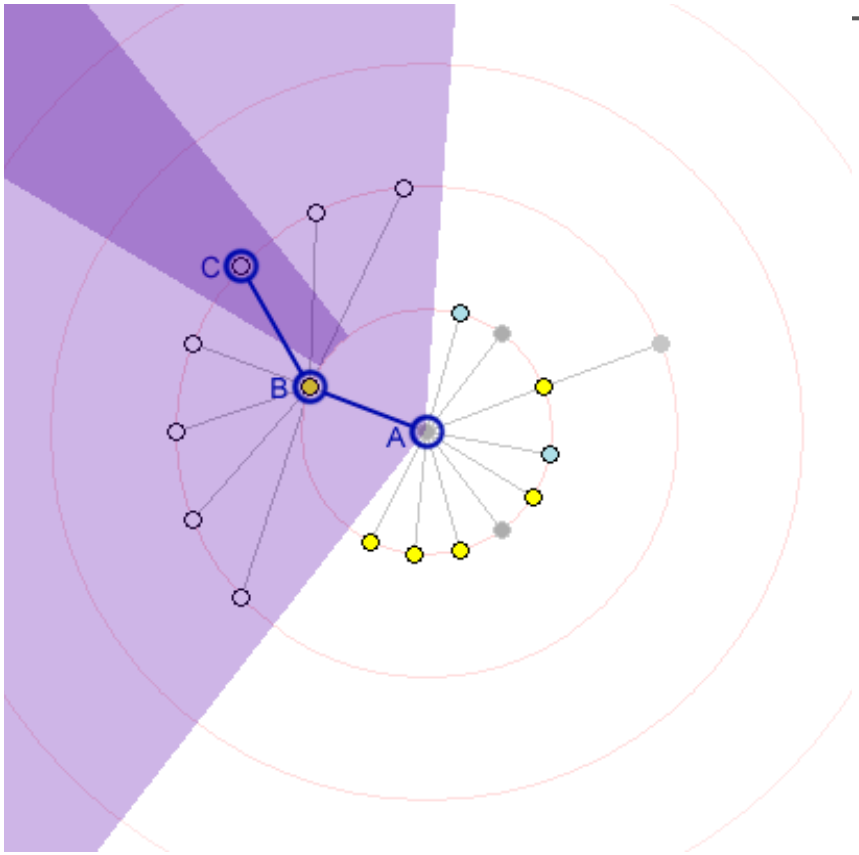
Animation to Improve Data Navigation: Gnutellavision

- Visualization of Peer-to-Peer Network
  - Hosts (with color for status and size for number of files)
  - Nodes with closer network distance from focus on inner rings
  - Queries shown; can trace queries

- http://www.youtube.com/watch?v=OPX5iGro_IA

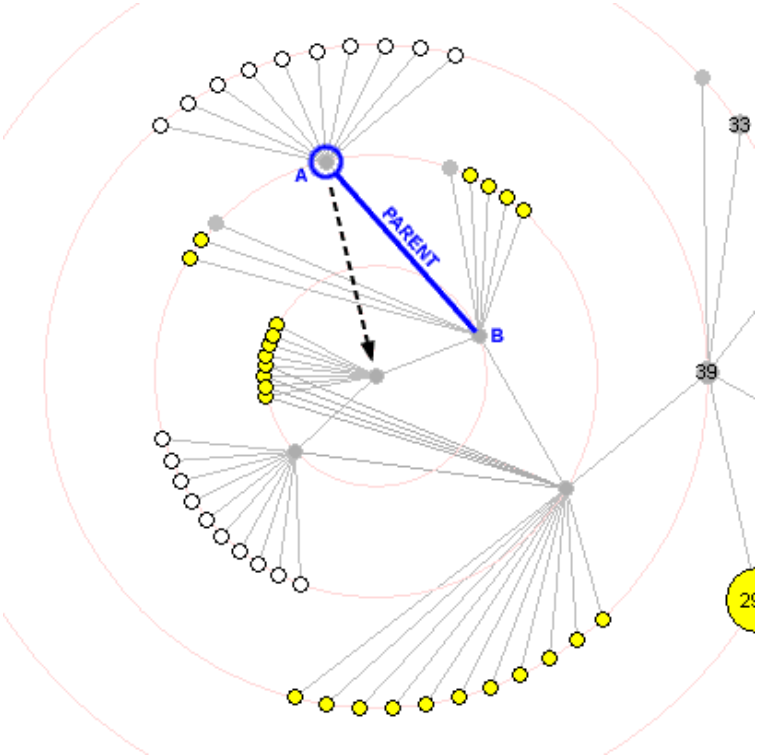
***Animated Exploration of Graphs with Radial Layout**, Ka-Ping Yee, Danyel Fisher, Rachna Dhamija, Marti Hearst, in IEEE Infovis Symposium, San Diego, CA, October 2001*

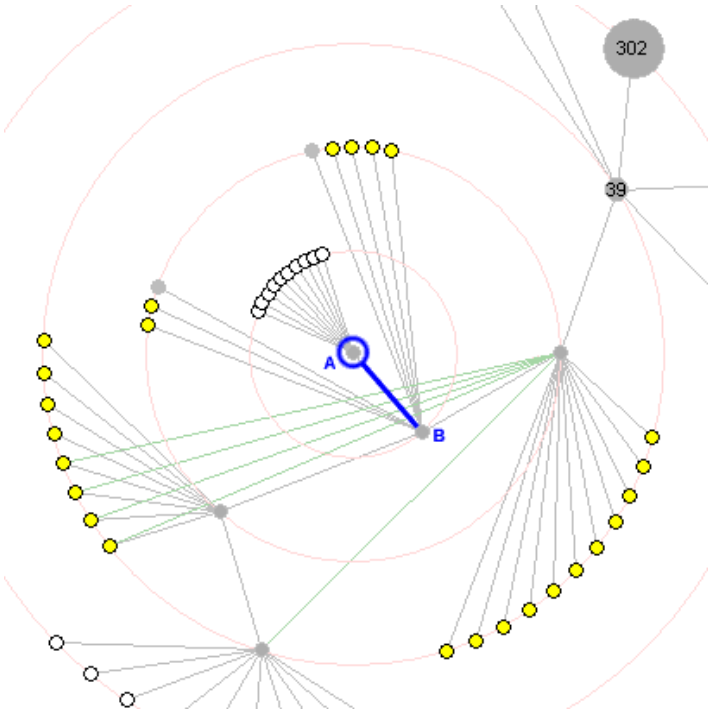
Maintaining smooth transitions



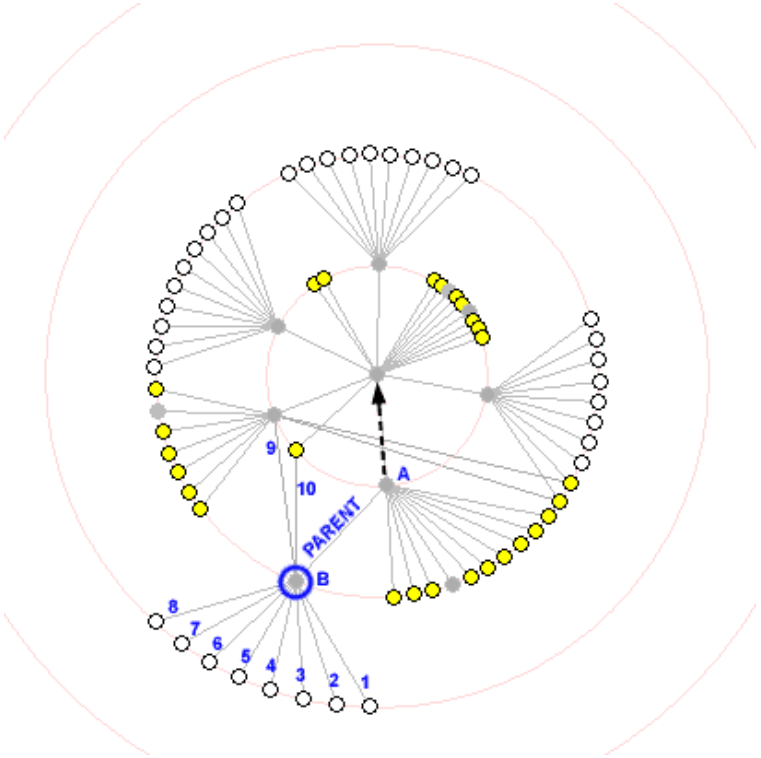
- Transition Paths
  - Linear interpolation of polar coordinates
  - Node moves in an arc, not straight lines
  - Moves along circle if not changing levels
  - When changing levels, spirals in or out to next ring

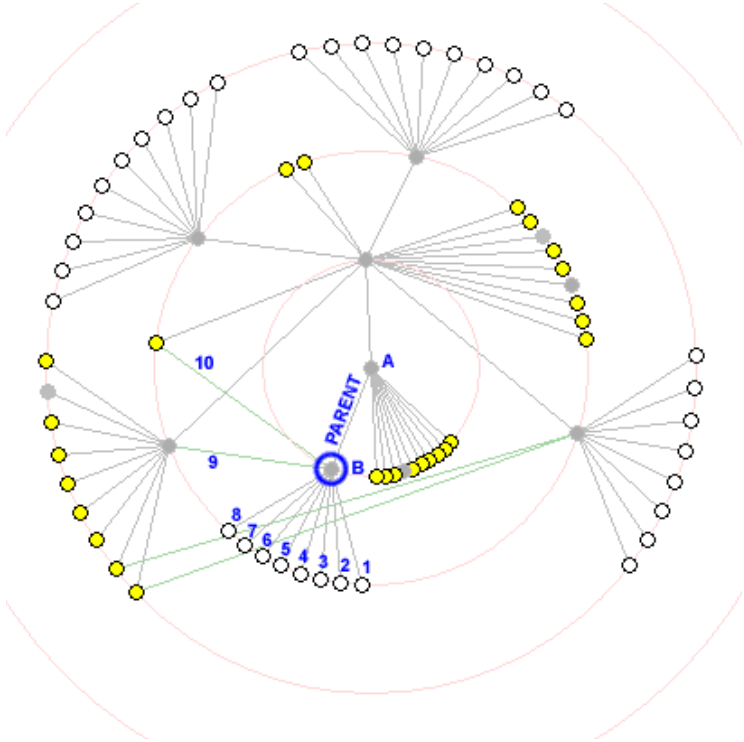
Transition Constraint – Retain Orientation of Edges



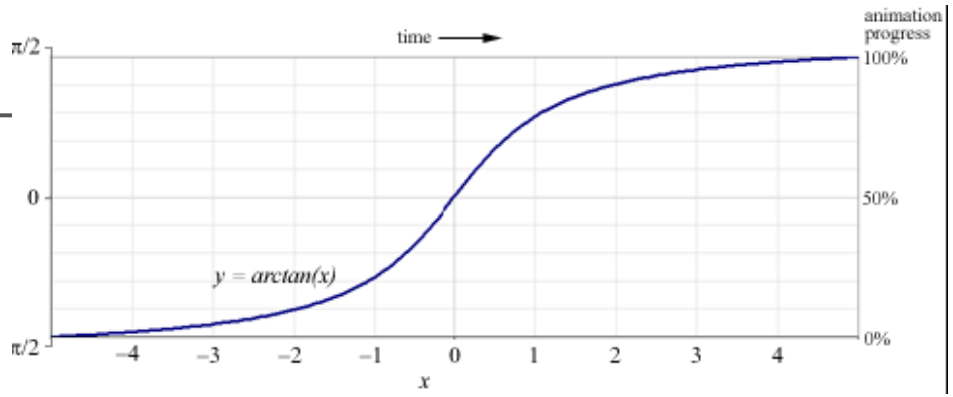


Transition Constraint – Retain Ordering of Neighbors





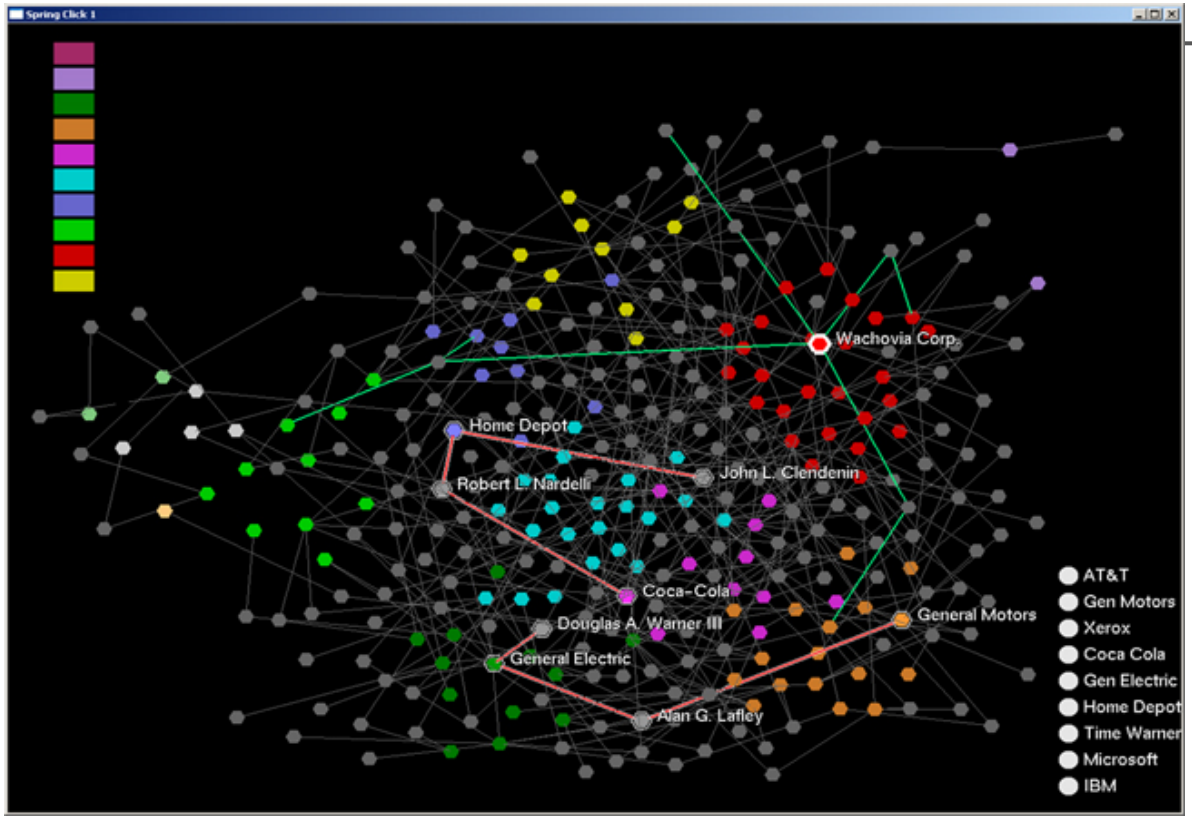
Gnutellavision (continued)



- Animation timing
  - Slow in Slow out timing (allows users to better track movement)

- Small usability study
  - Participants preferred version with animation for larger graphs

Brushing with motion



L. Bartram and C. Ware. Filtering and Brushing with Motion, Information Visualization 1(1), 2002.

Bobrow, Robert J., and Aaron Helsinger. "Kinetic visualizations: A new class of tools for intelligence analysis." Advanced Research and Development Activity (ARDA), National Geospatial-Intelligence Agency (NGA) (2005).

Which patterns are useful?

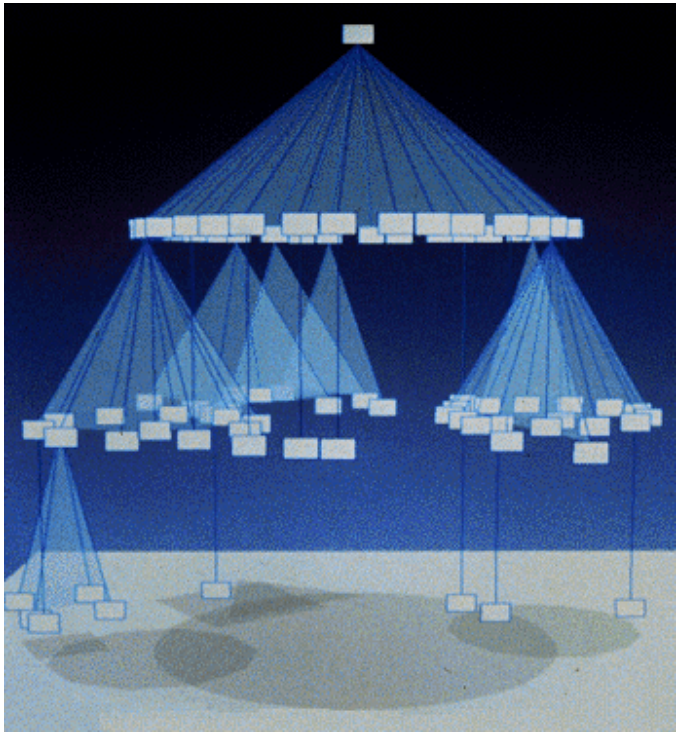
- Features shown to be perceptually powerful are
  - Phase (Ware)
  - Direction, flicker, velocity (Healey)
  - Shape (Bartram)

- Experiments show motion-based techniques very effective - but there are caveats
  - Distraction
  - Side effects and involuntary grouping

Motion shows transitions

- Helps the user retain context, see the response to an action.
- Examples:
  - Closing a window: it no longer just disappears; rather, it leaves a trail behind (demo)
  - Show animations during waiting times to indicate that processing is happening.
    - Airline flight search application
    - File download application

Example: Cone trees



Robertson, George G., Jock D. Mackinlay, and Stuart K. Card. "Cone trees: animated 3D visualizations of hierarchical information." Proceedings of the SIGCHI conference on Human factors in computing systems. ACM, 1991.

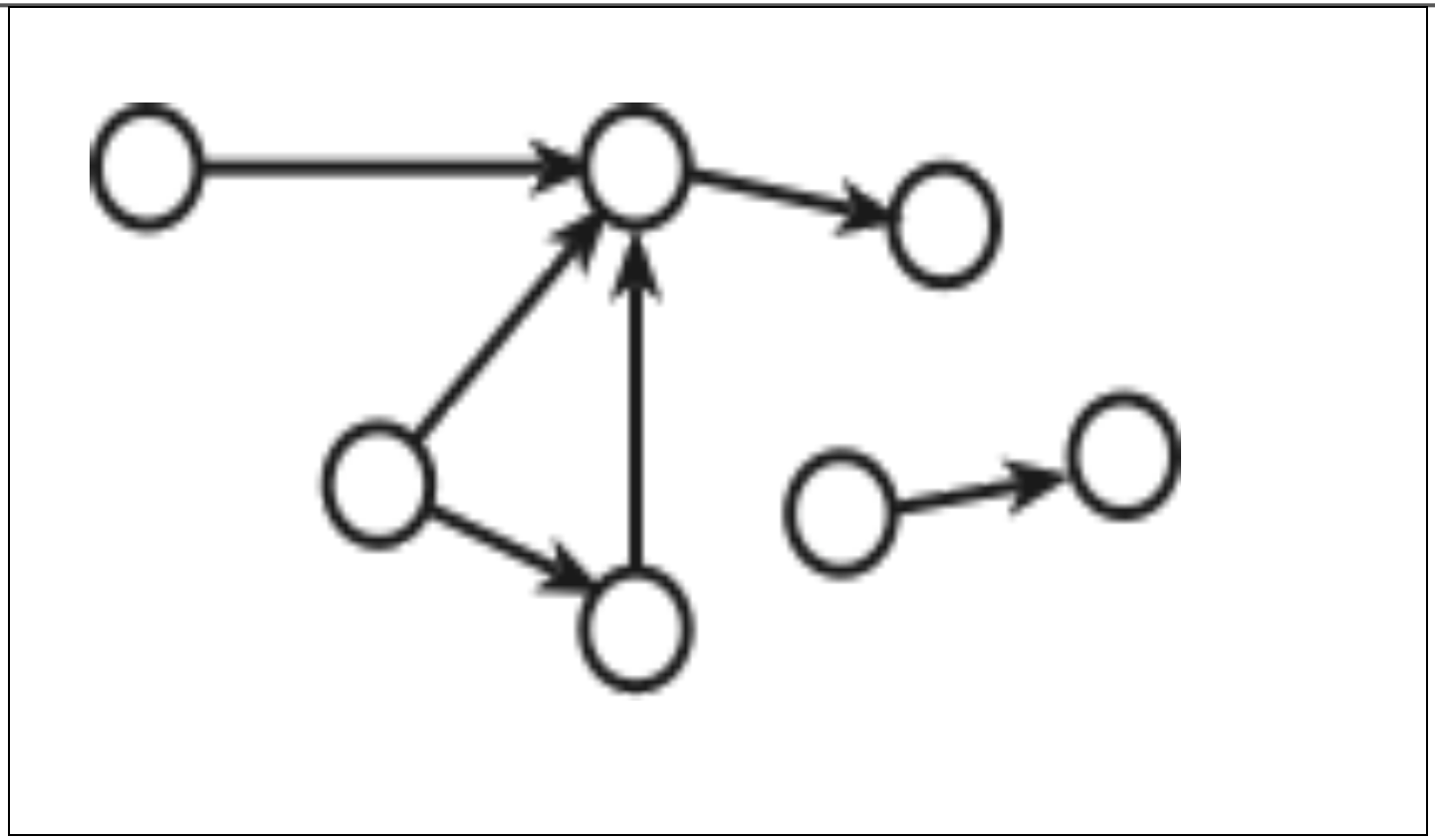
Causality

Michotte, Albert. "The perception of causality." (1963)

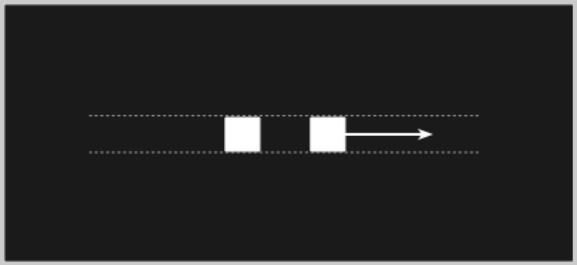
- Certain motion interactions give rise to the perception that moving object A caused a change in moving object B

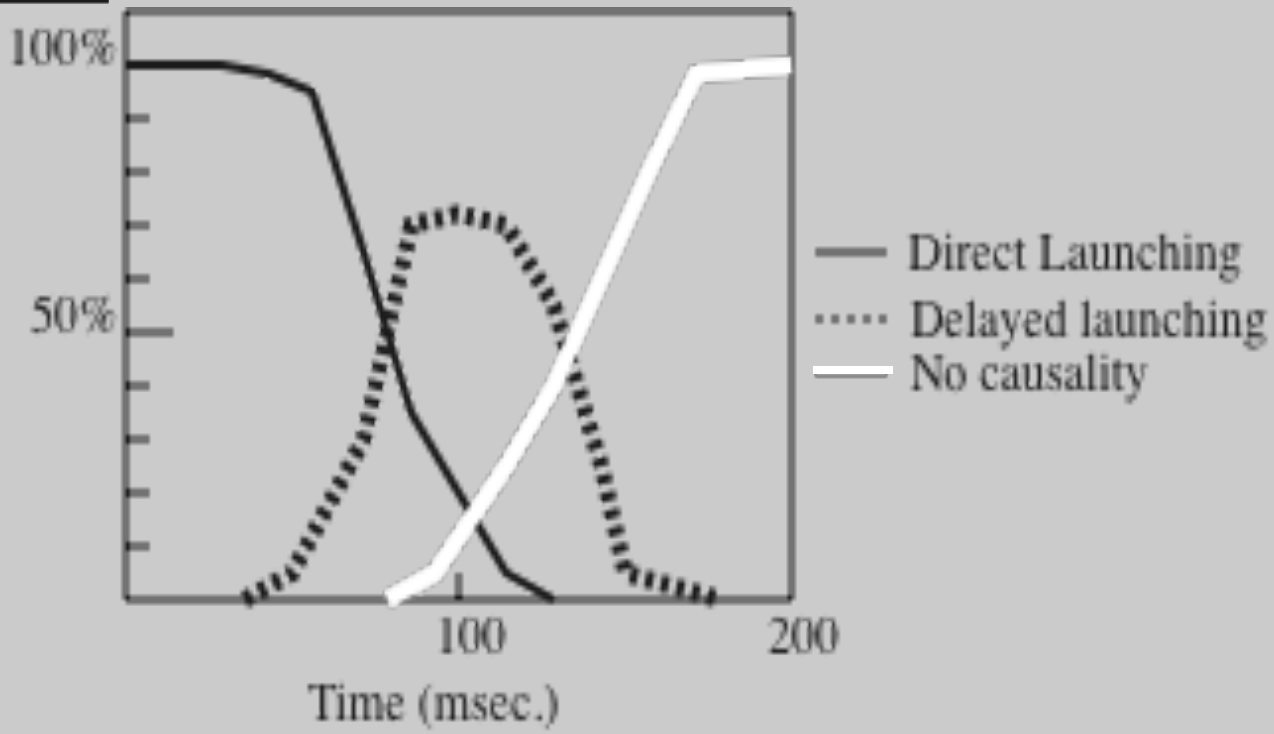
http://cogweb.ucla.edu/Discourse/Narrative/michotte-demo.swf

A causal graph



Michotte's Causality Perception





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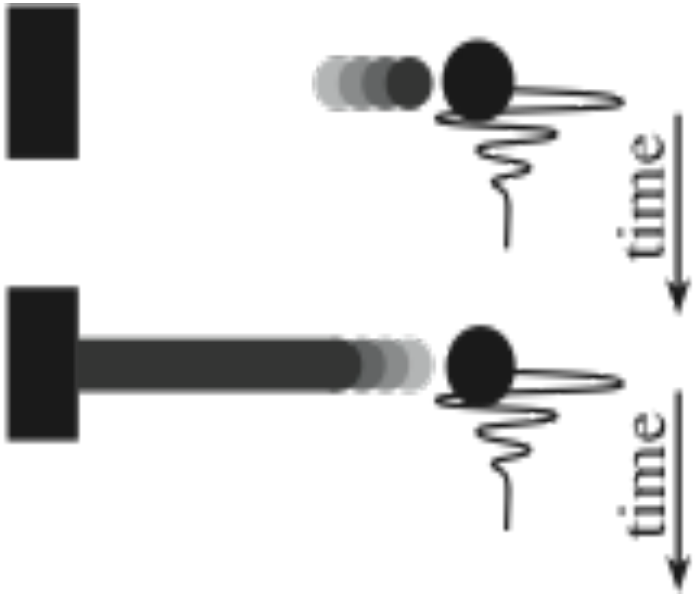
Visual Causal Vectors



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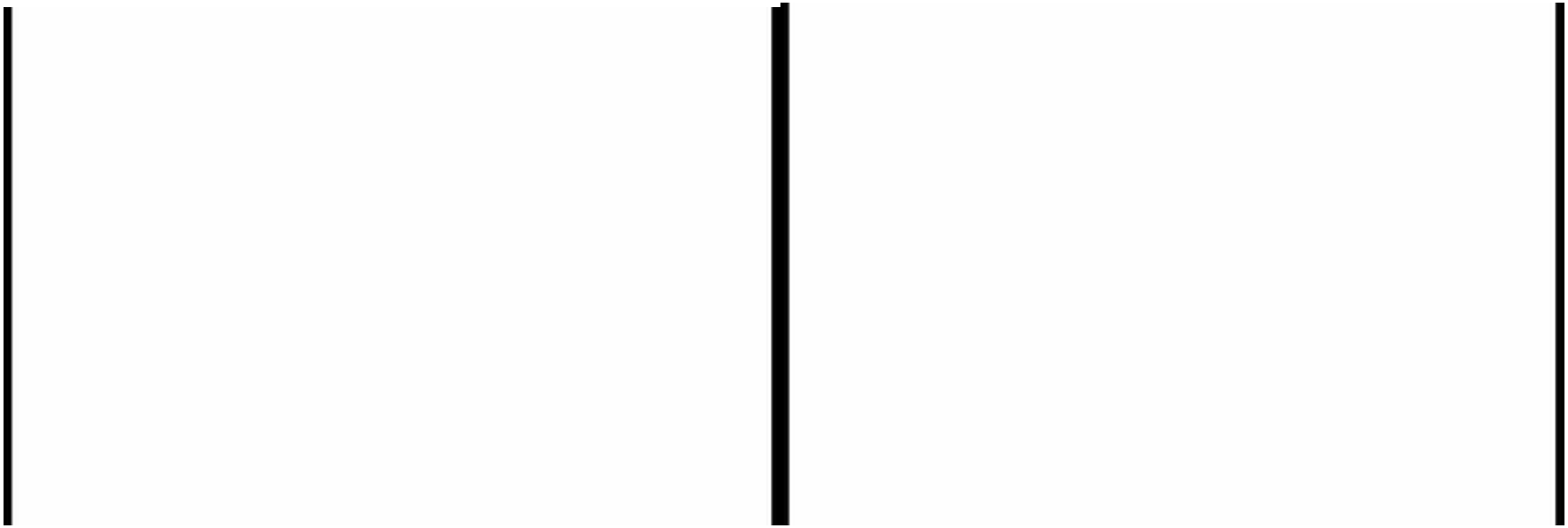
Current work on causality

- Scholl et al. (perception of causality)
- Neufeld, Ware, Bartram, Irani
- Yao and Bartram - using motion to overlay causality on other views
  - E.g. maps and graphs
- Value: increase expressive range beyond that permitted by static diagrams

Causal motion

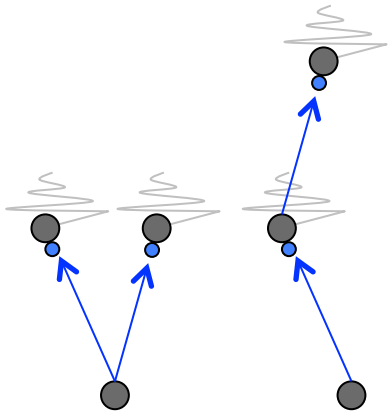
Bartram, Lyn, and Miao Yao. "Animating causal overlays." Computer Graphics Forum. Vol. 27. No. 3. Blackwell Publishing Ltd, 2008.



Bartram, Lyn, and Miao Yao. "Animating causal overlays." Computer Graphics Forum. Vol. 27. No. 3. Blackwell Publishing Ltd, 2008.

What we discovered

- We can successfully use motion cues to identify paths
- Causal effect :animate path and maintain timing (70-160 ms)
  - Vector effect
- Causal strength:use some kind of node interaction
  - Node effect
- With small node effects, we can identify whether one causal hit is stronger than another
  - Phase and grouping effects
- need to explore design space



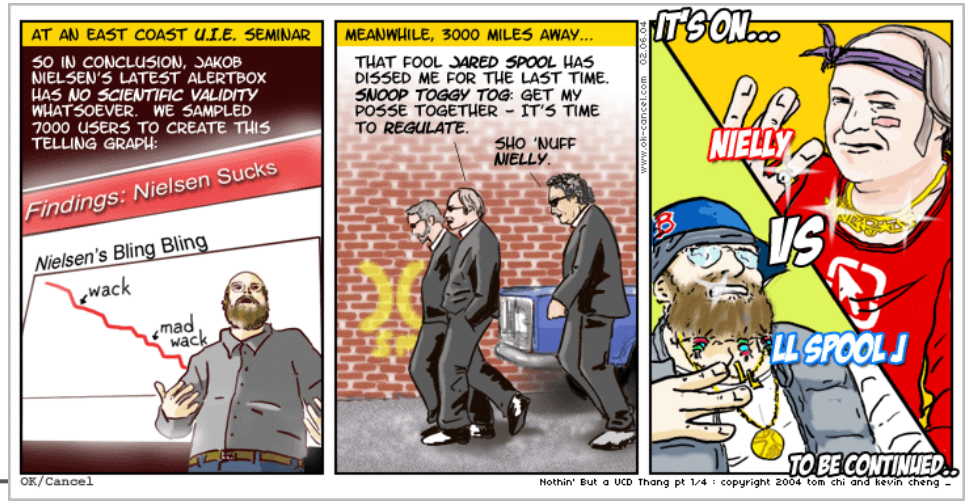
Cartoon-Style Animation

- Main Reference
  - Chang & Unger, Animation: From Cartoons to the User Interface, UIST ’93
- Main ideas
  - Visual change in the interface can be sudden and unexpected
  - User can lose track of causal connection between events
    - Classic example: closing/opening windwos
    - This is now remedied via animation in standard windows interfaces
- People have no trouble understanding transitions in animated cartoons
  - They grow and deform smoothly
  - They provide visual cues of what is happening before, during, and after a transition.

Cartooning Principles to Enhance Animation

- Replace sudden transitions with smooth ones
- Solidity (squash and stretch)
  - Motion blur
  - Dissolves
  - Arrival and departure (from off-screen)
- Exaggeration
  - Anticipation
  - Follow through
- Reinforcement
  - Slow in and slow out
  - Arcs
  - Follow through

Johnston and Thomas, The Illusion of Life. Disney, 1981.



Staging

- Clear presentation of one idea at a time
- Highlight important actions

- Lead viewers' eyes to the action
- Motion in still scene, stillness in busy scene
- Motion clearest at silhouette

Principles for Animation

- Animated Presentations
- Make all movement meaningful
- Avoid squash-and-stretch, exaggeration
- Use anticipation and staging
- Do one thing at a time

Douglas E. Zongker and David H. Salesin. 2003. On creating animated presentations. In Proceedings of the 2003 ACM SIGGRAPH/Eurographics symposium on Computer animation (SCA '03). Eurographics Association, Aire-la-Ville, Switzerland, Switzerland, 298-308.

Animation in Instruction

- Many studies are inconclusive
- Positive results
  - Best when animation and explanation are simultaneous
  - Students need to be able to step through, control speed
  - Students were more accurate and enjoyed the work more with animation.
- Animation can provide insight when the pattern can only be seen aided by change and motion

Issues with animation

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

Barbara Tversky, Julie Bauer Morrison, and Mireille Betrancourt. 2002. Animation: can it facilitate?. Int. J. Hum.-Comput. Stud. 57, 4 (October 2002), 247-262

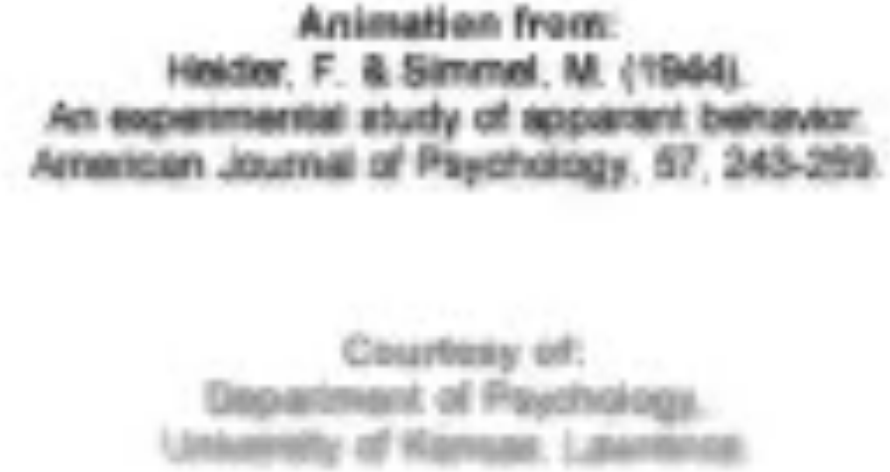
Animation: Summary

	Helps?	**Hurts?**
Attention	Directs attention	distraction
Object constancy	Change tracking	False relations
Causality	Cause and effect	False causality
Grouping/Brushing	Sets groups	False association
Engagement	Increase interest	“chart junk”
Calibration		Too slow Too fast
		Too unknown?

Animation: Summary

- Is useful to help indicate changes in state in a visualization.
- Is captivating, helps tell a story.
  - Compelling in process and algorithm visualization
- Can give the big picture, but maybe not so useful for comprehension of details compared to well-chosen stills.
  - Certain animation techniques are commonly used and seem natural to understand.
  - Seems better for **synthesis** instead of **analysis**

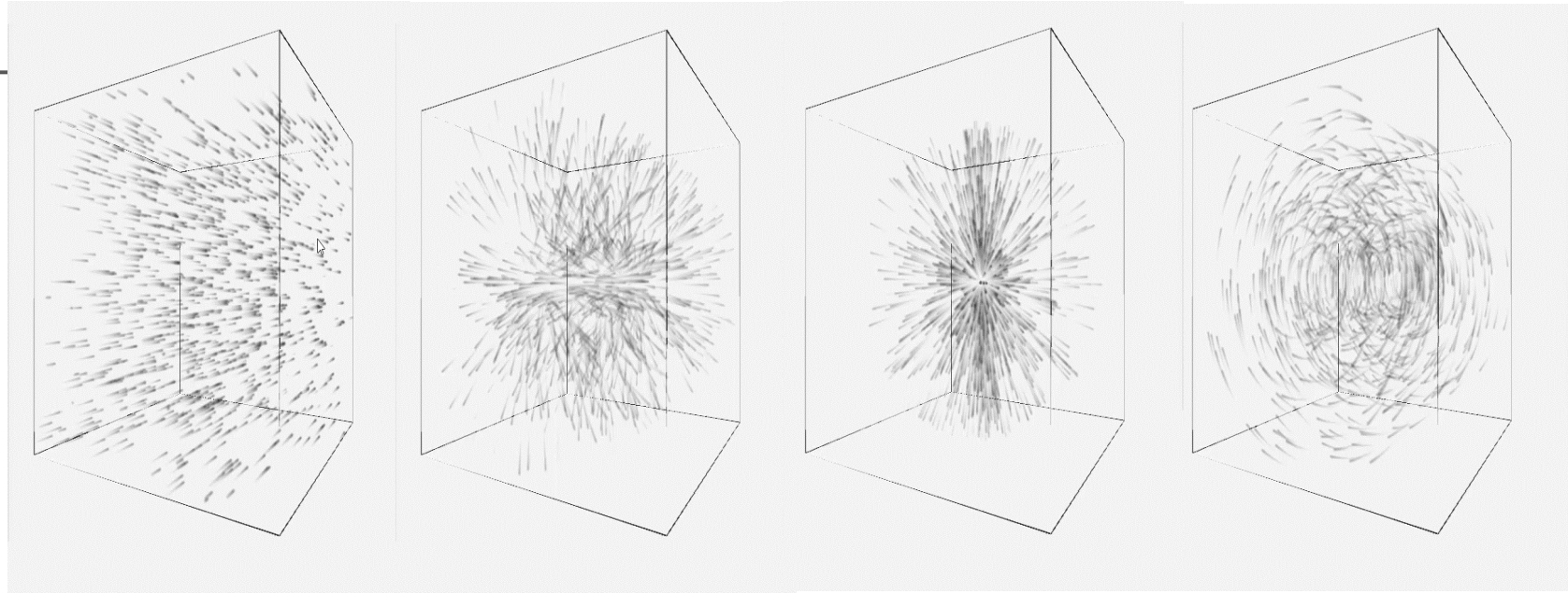
Motion tells stories and evokes experience



Affective motion

- Motion is expressively rich (dance, theatre, mime, ….)
- What are the properties of motion that make it so expressive?
- Trajectory [Tagiuri], interaction [Lethbridge+Ware, Heider+Simmel, etc], smoothness vs jerkiness, velocity, acceleration, amplitude ???
- Experiments in what contributes to making motions meaningful
  - Application in ambient, social and therapeutic interfaces and visualizations
  - Represent emotion
  - Evoke response rather than represent data

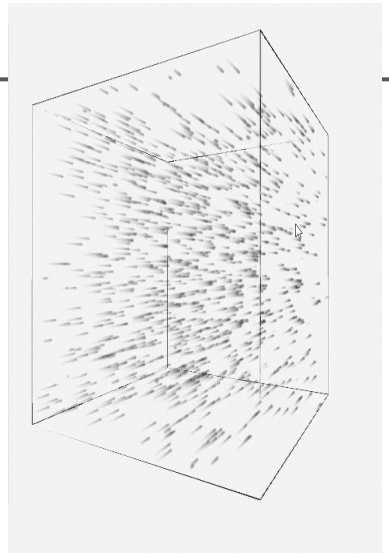
Shape as Compositional Base

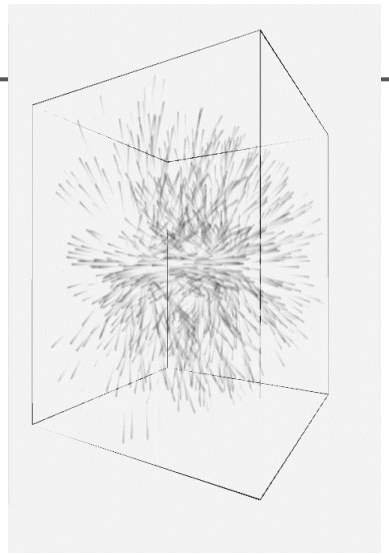


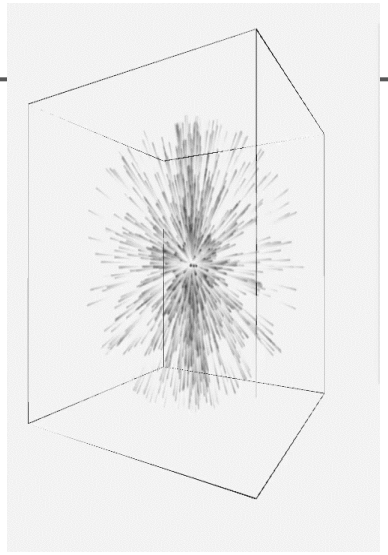
Linear *Radial* *Spherical* *Circular*

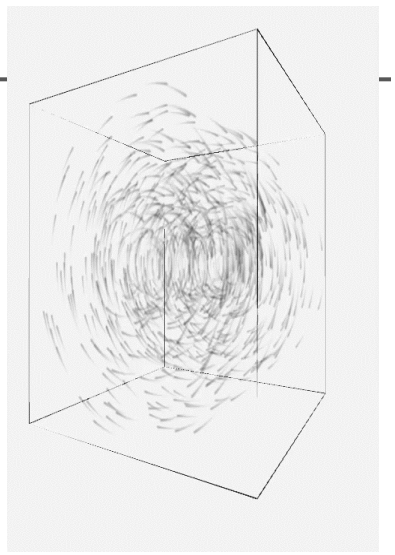
SFU

Affectively Different









Linear
Positive, Calming, Relaxed, Reassuring, and Attracting

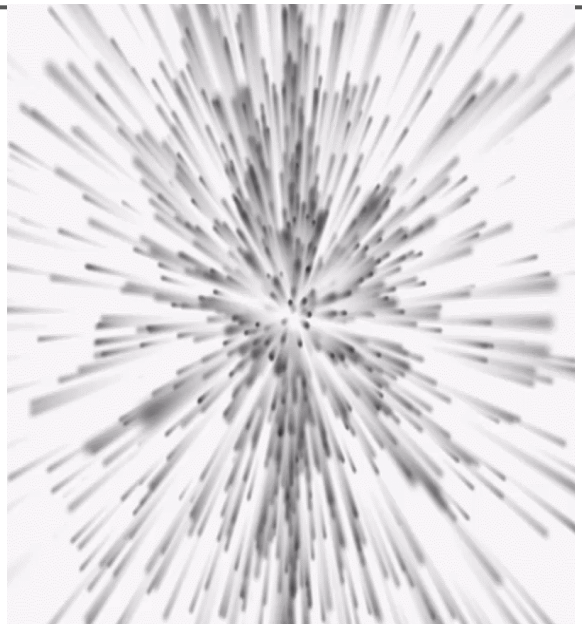
Radial

Spherical
Negative, Exciting, Urgent, Threatening, and Rejecting

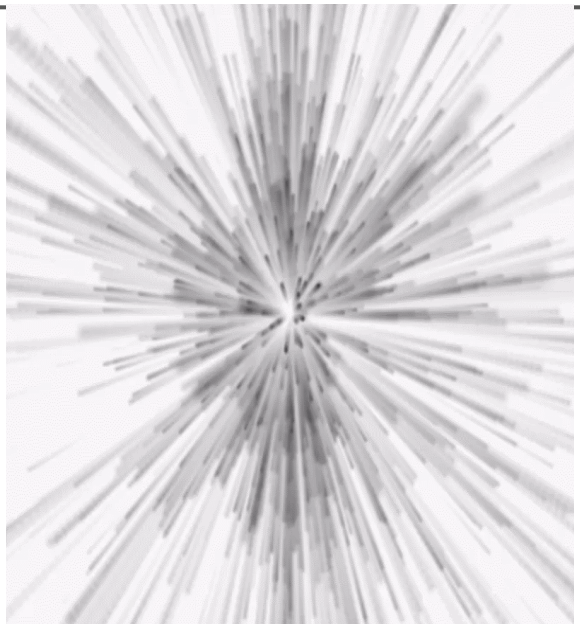
Circular

SFU

Speed

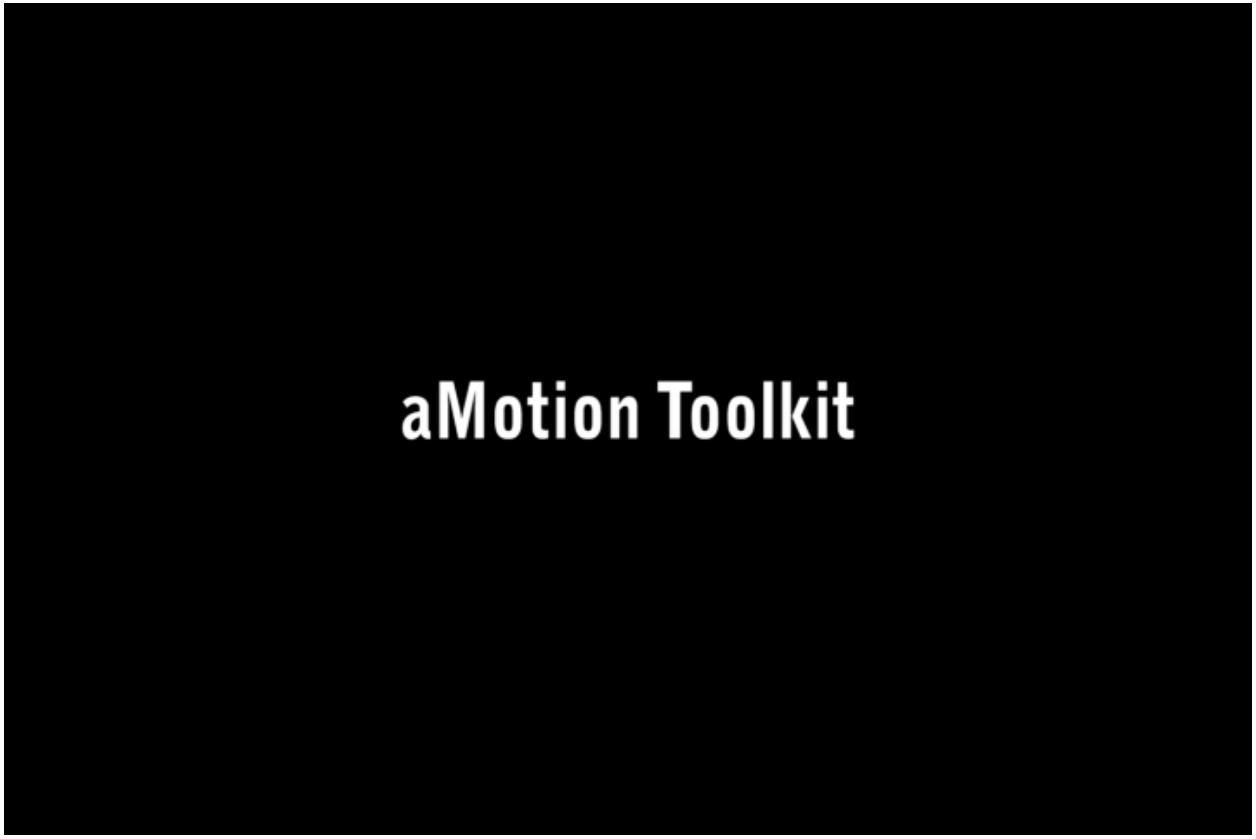


positive, calming, relaxed, reassuring, and attracting



negative, exciting, urgent, threatening and rejecting

SFU


aMotion Toolkit