Static and Moving Patterns
(part 2)

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IAT 814 week 9
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Administrivia

- Assignment 3
- Final projects
Transparency and layering

- Transparency affords several visual impressions
- Layering
- “haziness” or uncertainty
- Perceptual pitfalls
Perceptual cues

Continuity is important in transparency

- Ratio of colour or grey
  - $x < y < z$ or $x > y > z$
  - $y < z < w$ or $y > z > w$
Transparency

- Rotating disk with gaps – luminance integration
- (Metelli)

- Direction of contrast – Xjunctions
- (Cavanaugh)
Laciness (Cavanaugh)

- Layered data: be careful with composites of textures
- Similar patterns perceptually interfere (last week)
- Overlay menus and images need perceptually strongly distinct channels

b is a distinct patch

b is a distinct patch

c is one, d is “bistable”
Patterns in Diagrams

- Patterns applied to node-link diagrams
Node-link diagrams

• Most common way of showing relation

• Node == entity, object
  ▪ Closed contour

• Link == relation

• Visual grammar has a perceptual basis for how it conveys meaning
- Visual grammar for node-link diagrams
- Static patterns

<table>
<thead>
<tr>
<th>Graphical Code</th>
<th>Visual Instantiation</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Shape of closed region.</td>
<td></td>
<td>Entity type.</td>
</tr>
<tr>
<td>5. Partitioning lines within enclosed region.</td>
<td></td>
<td>Entity partitions are created, e.g., TreeMaps.</td>
</tr>
<tr>
<td>7. Shapes enclosed by contour.</td>
<td></td>
<td>Contained entities.</td>
</tr>
<tr>
<td>10. Linking-line quality.</td>
<td></td>
<td>Type of relationship between entities.</td>
</tr>
<tr>
<td>12. Tab connector.</td>
<td></td>
<td>A fit between components.</td>
</tr>
</tbody>
</table>
Visual Grammar of diagrams

Connecting contour

Enclosing contour

Proximity grouping

Alignment

Common movement

Common color region

Common texture region

Nested regions

Overlapping regions

Entities related across regions

Multiple heterogeneous relationships

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Semantics of structure

<table>
<thead>
<tr>
<th>Graphical Code</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapes connected by contour</td>
<td>Related entities, path between entities</td>
</tr>
<tr>
<td>Thickness of connecting contour</td>
<td>Strength of relationship</td>
</tr>
<tr>
<td>Color and texture of connecting contour</td>
<td>Type of relationship</td>
</tr>
<tr>
<td>Shapes enclosed by a contour, or a common texture, or a common color</td>
<td>Contained entities. Related entities</td>
</tr>
<tr>
<td>Nested regions, partitioned regions</td>
<td>Heirarchical concepts</td>
</tr>
<tr>
<td>Attached shapes</td>
<td>Parts of a conceptual structure</td>
</tr>
</tbody>
</table>
Grammar of maps

• Common features of geographic maps
  ▪ Areas,
  ▪ line features
  ▪ point features
Maps

- Visual grammar of maps

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</tr>
</thead>
<tbody>
<tr>
<td>4. Line.</td>
<td>![Line]</td>
<td>Linear map features such as rivers, roads, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depends on scale.</td>
</tr>
<tr>
<td>5. Dot.</td>
<td>![Dot]</td>
<td>Point features such as town, building.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depends on scale.</td>
</tr>
<tr>
<td>6. Dot on line.</td>
<td>![Dot on Line]</td>
<td>Point feature such as town on linear feature such as road.</td>
</tr>
<tr>
<td>7. Dot in closed contour.</td>
<td>![Dot in Closed Contour]</td>
<td>Point feature such as town located within a geographic region.</td>
</tr>
<tr>
<td>8. Line crosses closed-contour region.</td>
<td>![Line Crosses Contour]</td>
<td>Linear feature such as river crossing geographic region.</td>
</tr>
<tr>
<td>9. Line exits closed-contour region.</td>
<td>![Line Exits Contour]</td>
<td>A linear feature such as a river terminates in a geographic region.</td>
</tr>
<tr>
<td>10. Overlapping contour, colored regions, textured regions.</td>
<td>![Overlapping Contour]</td>
<td>Overlapping geographically defined areas.</td>
</tr>
</tbody>
</table>
Treemaps and hierarchies

- Treemaps use areas (size)
- SP tree
- Graph Trees use connectivity (structure)
Part II: Patterns in Motion

• How can we use motion as a display technique?

• Gestalt principle of common fate

• Motion is very perceptually powerful
Limitation due to Frame Rate

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

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Motion as a visual attribute (Common fate)

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

- Group moving objects in hierarchical fashion.
Frame as motion context

- The stationary Dot is perceived as moving in (a).
  - *Vection*

- The circle has no effect on this process in (b).

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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

- **Demo 1**: [http://psych.hanover.edu/Krantz/MotionParallax/MotionParallax.html](http://psych.hanover.edu/Krantz/MotionParallax/MotionParallax.html)

- **Demo 2**: [http://www.psypress.co.uk/mather/resources/swf/Demo10_2.swf](http://www.psypress.co.uk/mather/resources/swf/Demo10_2.swf)
Patterns in motion
Motion patterns – what works?

- Rich literature for design of static representations
- Motion perceptually powerful but no principled guidelines for use

- 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
  - false association

- Empirically based guidelines for appropriate use
Potential uses?

• **Signaling**: cognitive tools for managing attention
  ▪ events (external dynamic information)
  ▪ markers (navigation, history, guides)

• **Grouping**:
  ▪ linking heterogeneous, scattered elements (brushing)
  ▪ filtering in context

• **Current codes have limitations**:
  ▪ over-use and saturation
  ▪ poor detection outside focal area (*acuity*)
Why Motion?

- Perceptually efficient
  - strongest cue across entire visual field
  - track multiple motions in parallel [Pylyshyn]
Why Motion?

- Perceptually efficient

- Interpretatively rich
  - Rich disciplines of expression and performance
  - Socially meaningful (Heider, Kassin)
  - motion conveys structure and behaviour [Johanssen, Heider, Cutting, Berry]
Why Motion?

- Perceptually efficient
- Interpretatively rich
- “free” display dimension?
Why Motion?

• Perceptually efficient
• Interpretatively rich
• “free” display dimension
• grouping effect:
  ▪ conveys relationships [Bartram, Ware, Michotte, Alvarado]
Moticons for coding and notification

- Three empirical studies:
  - Which motion features are useful for signals?
    - Large fields of view
  - How do motions contribute to distraction?
  - Features for grouping
    - Filtering
    - Brushing (association)
- 6 shapes
- 2 colour cues: RED and GREEN
6 shapes
2 colour cues: RED and GREEN
Results

• Detection:
  ▪ Moticons were extremely accurately detected
  ▪ Location had large error effect on static cues
    • colour: 5% and 24% error rates
    • shape: 4% and 15% error rates
  ▪ Location doubled static detection times; moticons were constant

• Identification – as above
  ▪ colour: 14% and 19% error rates (of detected)
  ▪ Moticons highly accurate: ~ 1% error
Motion types

- Demo
- file:///Users/lyn/Research/Motion/Dev/MotionExperiments/Applets/distraction.html
Conclusions: Moticons for cueing attention, but…

- Moticons very effective for signaling
  - better than colour and shape, especially in periphery
  - Effective over many locations, types and amplitudes

- Certain motion shapes are more distracting
  - traveling worse than anchored
  - linear shape good candidate: detectable but not distracting

- Task load affects detection
  - signal can be tuned to task
  - Signal can indicate engagement?
Filtering and brushing

• User configures display to make information easily accessible and show subgroups

• **filtering** takes away superfluous data

• **Brushing** highlights data points interactively and visually connects arbitrary distributed objects [Baecker and Cleveland87]
  - brushing requires its own brushing code (colour)
  - problems with colour in periphery

• Motion can be used for brushing and filtering
Recall …

- **strong grouping effect**: things which move together in a similar fashion elicit percept they are a group

- [file:///Users/lyn/Research/Motion/Dev/MotionExperiments/Applets/OneGroup.html]
Questions

• What does it mean to move in a “similar way”?

• Similarity tolerance so that we can cause effect when desired (*grouping*); and

• ensure that multiple unrelated moving objects are perceived as distinct (*discrimination*).
  ▪ (caveat!) Applies to many environments
Brushing with motion

- Dual task visual search experiments
- High level of distractors
- **17 motion combinations**
  - [file:///Users/lyn/Research/Motion/Dev/MotionExperiments/Applets/TwoGroups.html](file:///Users/lyn/Research/Motion/Dev/MotionExperiments/Applets/TwoGroups.html)
Results

- Motion groups “pop out”
- Motion type is most effective feature for both ranking and discrimination
- Circular type is most visually dominant
- Motion directions blur together < 45° and at 180°
- Large effect for quadrant change
- Motions work for brushing
- Care has to be taken for involuntary grouping
Visualizing relationships

• Preliminary work in representing causality
  ▪ with Colin Ware (1999)
  ▪ With Emily Yao (2007)

• Based on Michotte

• Can we overlay causality information on existing representations like spreadsheets and graphs?
Perception of causality from motion

- Michotte’s claim: direct perception of causality
- Precise timing is required to achieve perceived causality.
Using motion to display causality

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A causal graph
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
What we discovered

- We can successfully use motion cues to identify paths
- If we want to show just the existence of the causal path, it’s sufficient to animate path and maintain timing (70-160 ms)
  - Vector effect
- However, if we want to add information about the strength of the effect we have to 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
Meaningful 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 [Bartram+Nakatani] in what contributes to making motions meaningful
  ▪ Application in ambient, social and therapeutic interfaces and visualizations
  ▪ Map emotions to more abstract meanings
  ▪ demo
Conclusion

• Motion is under-researched, but evidence suggests its power.

• Initial usable features include velocity, direction, phase, shape (type) and flicker/blink

• There are interactions between motion features and static features that need to be investigated
  ▪ E.g. brighter dots generate stronger motion signals (Schwartz, 2000?)
    http://www.settheory.com/Glass_paper/Kanizsa_observations.html

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Pattern learning

• Can we learn to see patterns better?

• What is the scientific evidence that people can learn to see patterns better?

• The results are mixed.

• There have been some studies of pattern learning where almost no learning occurred.

• But other studies have found learning for certain patterns.
Pattern learning

• A plausible explanation is that pattern learning occurs least for simple, basic patterns processed early in the visual system, and most for complex, unfamiliar patterns processed late in the visual system.

• What are the implications of these findings for visualization?
Pattern learning

• One is that people can learn pattern-detection skills, although the ease of gaining these skills will depend on the specific nature of the patterns involved.

• Experts do indeed have special expertise.
  ▪ The power law of practice
  ▪ Radiologists, meteorologists, pilots, video editors
Pattern learning

- People who work with visualizations must learn the skill of seeing patterns in data.

- In terms of making visualizations that contain easily identified patterns, one strategy is to rely on pattern-finding skills that are common to everyone.

- Good idea to use *priming* to enhance perceptual receptivity
Pattern learning

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