Information Visualization and Visual Analytics (M1522.000500)

Rules of Thumb

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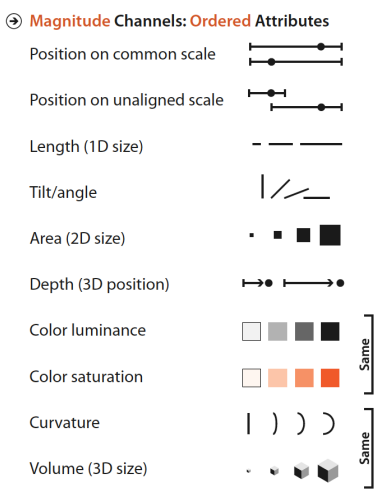
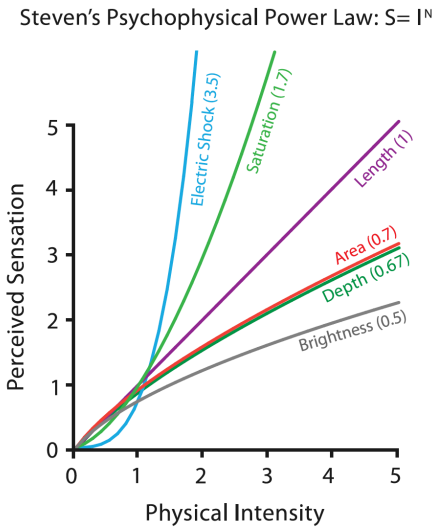
Overview

- No unjustified 3D
  - Power of the plane, dangers of depth
  - Occlusion hides information
  - Perspective distortion loses information
  - Tilted text isn't legible
- No unjustified 2D
- Eyes beat memory
- Resolution over immersion
- Overview first, zoom and filter, details on demand
- Function first, form next

Power of the Plane

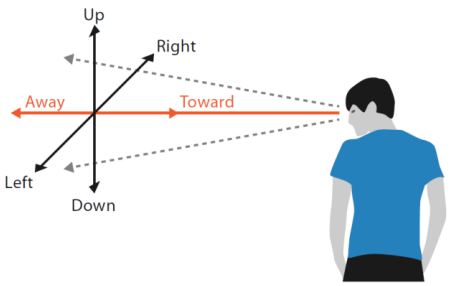
- high-ranked spatial position channels: **planar** spatial position
  - not depth!

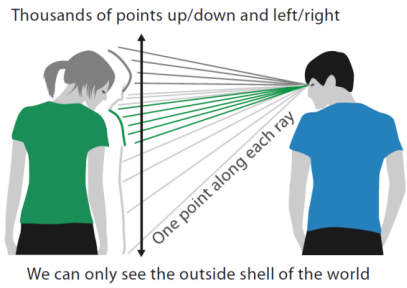




Danger of Depth

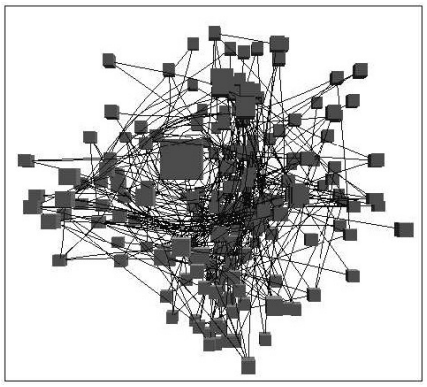
- we don't really live in 3D: we ***see*** in 2.05D
  - acquire more info on image plane quickly from *eye movements*
  - **line-of-sight ambiguity**: only get info at one point along the depth axis for each ray -> *head or even body movements* required to get more info





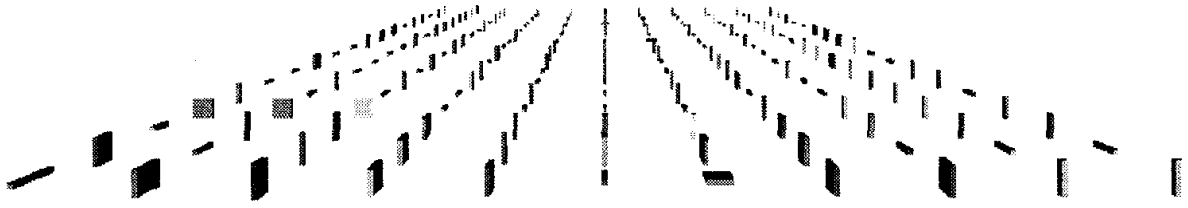
Occlusion Hides Information

- occlusion is the most powerful **depth cue**, but it could hide important information.
- interactive navigation (cf. motion parallax) is critical to see occluded info or to understand 3D
  -> takes more time
- must use internal memory to remember the shape from previous scene
- benefits of 3D are worth the cost?



Perspective Distortion loses information

- perspective distortion
  - distant objects look smaller and change their planar position on the image plane
  - interferes with all size channel encodings
  - power of the plane is lost! -> main dangers of depth

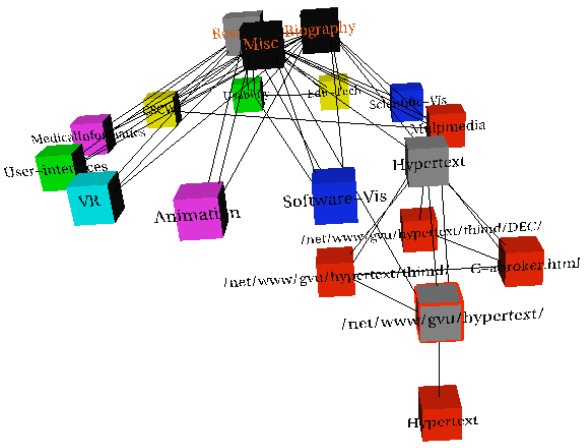


[Visualizing the Results of Multimedia Web Search Engines. Mukherjea, Hirata, and Hara. InfoVis 96]

No unjustified 3D

Tilted text isn't legible

- Node-Link vs. Text List
- text legibility
  - characters of 9 pixels height: readable in 2D
  - far worse when tilted from image plane



- further readings

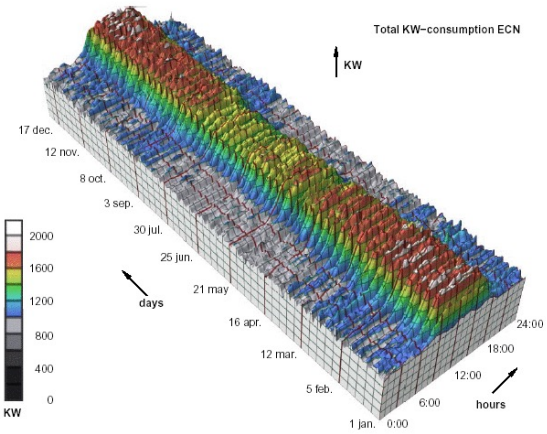
  [Exploring and Reducing the Effects of Orientation on Text Readability in Volumetric Displays. Grossman et al. CHI 2007]

[Visualizing the World-Wide Web with the Navigational View Builder, Mukherjea and Foley. Computer Networks and ISDN Systems, 1995.]

No unjustified 3D Example

Time-series data

- extruded curves -> occlusion and perspective distortion
- detailed comparisons impossible

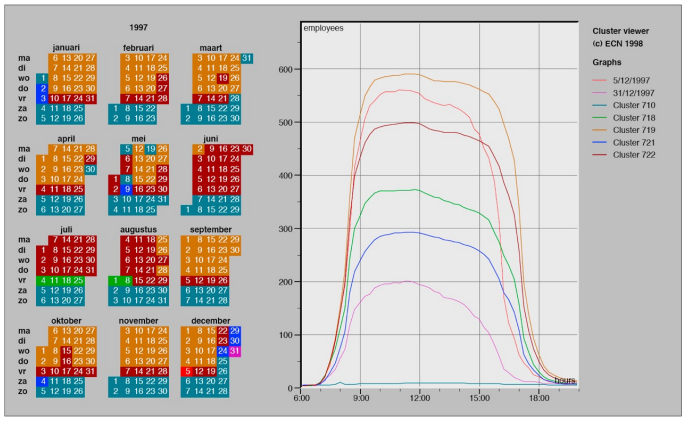


[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

No unjustified 3D

Transform for new data abstraction

- derived data: clusters by hierarchical clustering
- juxtapose multiple views: calendar, superimposed 2D curves



[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

Justified 3D

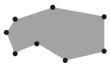
Shape Perception

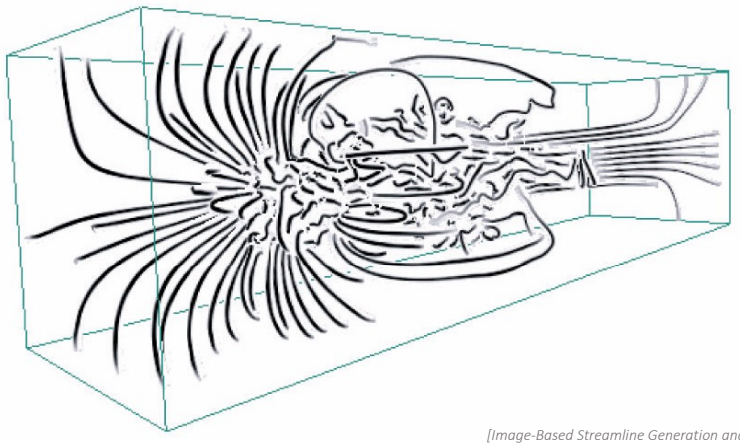
- benefits outweigh costs when task is shape perception for 3D spatial data
  - interactive navigation supports synthesis across many viewpoints

Targets

Spatial Data

→ Shape



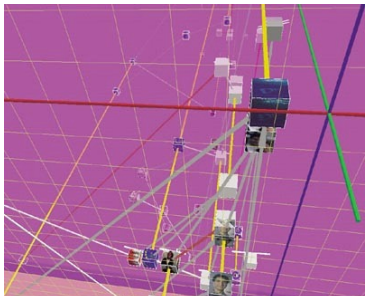


[Image-Based Streamline Generation and Rendering. Li and Shen. IEEE Trans. Visualization and Computer Graphics (TVCG) 13:3 (2007), 630–640.]

No unjustified 3D

literally 3D vs. abstract

- 3D legitimate for true 3D spatial data
- 3D needs very careful justification for abstract data
  - enthusiasm in 1990s, but now skepticism
  - be especially careful with 3D for point clouds or networks

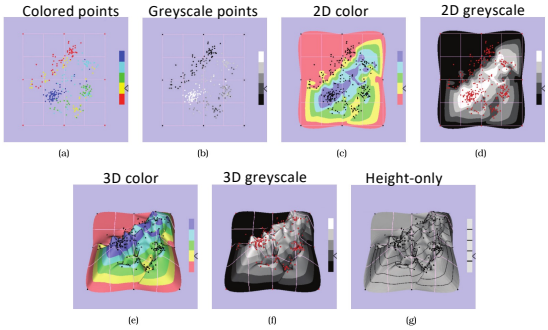


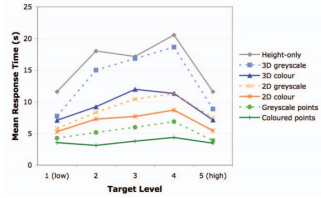
[WEBPATH-a three dimensional Web history. Frecon and Smith. Proc. InfoVis 1999]

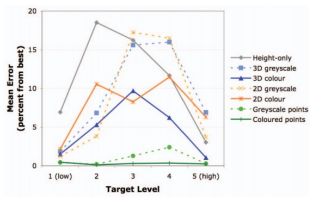
No unjustified 3D

Empirical Evidence

- Most tasks involving abstract data do not benefit from 3D
- e.g., comparing points and landscapes [Tory et al. 07]
  - Points > 2D landscapes > 3D landscapes for search and point estimation tasks
  - identify which spatial area contained the most points of a specified target value range







M. Tory, D. Sprague, F. Wu, W. Y. So and T. Munzner, "Spatialization Design: Comparing Points and Landscapes," in *IEEE Transactions on Visualization and Computer Graphics*, vol. 13, no. 6, pp. 1262-1269, Nov.-Dec. 2007, doi: 10.1109/TVCG.2007.70596.

No unjustified 3D

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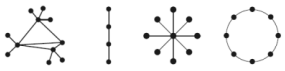
information density and structure in visualizing network data

- consider whether network data requires 2D spatial layout
  - especially if reading text is central to task!
  - arranging as network means ***lower information density*** and ***harder label lookup*** compared to text lists
- benefits outweigh costs when topological structure/context important for task
  - be especially careful for search results, document collections, ontologies

Targets → **Network Data**

→ Topology



→ *Paths*

Eyes beat memory

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Recognition vs. Recall

- principle: **external cognition** vs. **internal memory**
  - *easy* to compare by moving eyes between side-by-side views
  - *harder* to compare visible item to memory of what you saw
- implications for animation
  - great for choreographed storytelling
  - great for transitions between **two** states → **Blink Comparator** idiom
  - poor for many states with changes everywhere
    - consider small multiples instead

Eyes Beat Memory

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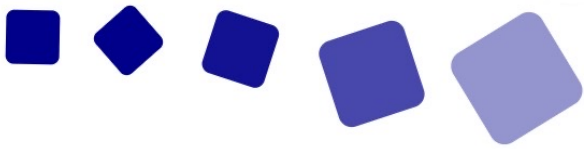
in terms of cognitive load

- Eyes > Memory
  - Switch between multiple views > Navigation within a single view
- Working memory (= short-term memory)
  - is a very limited resources (7+/-2)
  - *Cognitive load* occurs when the limits are reached



- Animation
  - also relies on memory
  - as transitions from one state to another,
    - powerful when the change occurs **within our attention**
  - as sequences of many frames (=multi-frame animation),
    - **side-by-side multiple views** can be more effective when frames are small enough

Eyes Beat Memory example: Cerebral

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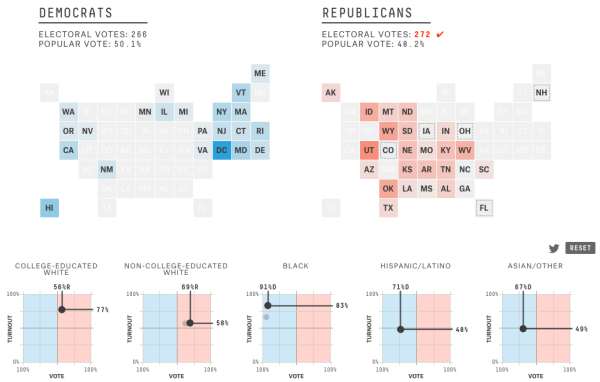
in terms of cognitive load

- switch between different views visible simultaneously

  vs. compare the current with what was seen before

- small multiples: one graph instance per experimental condition
  - same spatial layout
  - color differently, by condition
  - encourage comparisons



Change Blindness

- Change Blindness
  - when we fail to notice **drastic** changes **if our attention is directed elsewhere**

→ Hard to track Complex and widespread changes in multi-frame animations

human attention limitation

- disparate frames and regions: comparison difficult
  - vs contiguous frames
  - vs small region
  - vs coherent motion of group

- change blindness
  - even major changes difficult to notice **if mental buffer wiped**

Why not animation?

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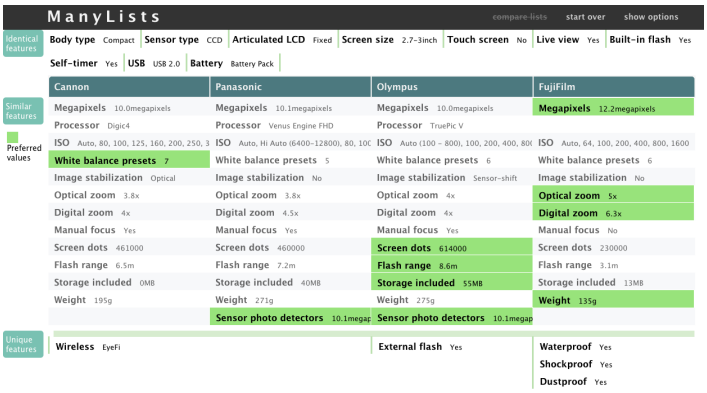
Multi-Step Animation for Understanding Spatial Groupings

- safe special case: animated transitions
  - extremely powerful when used for transitions between two configurations
  - help maintain context (video)



http://www.cs.umd.edu/hcil/manylists/

Resolution beats Immersion

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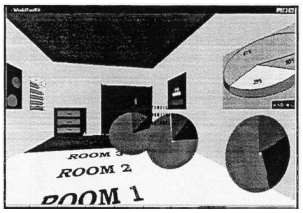
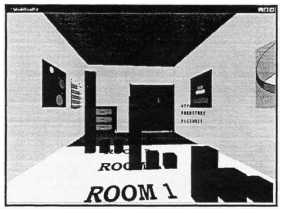
VR AR for InfoVis?

- immersion typically not helpful for abstract data
  - do not need sense of presence or stereoscopic 3D
- resolution much more important
  - pixels are the scarcest resource
  - desktop also better for workflow integration





- virtual reality for abstract data very difficult to justify

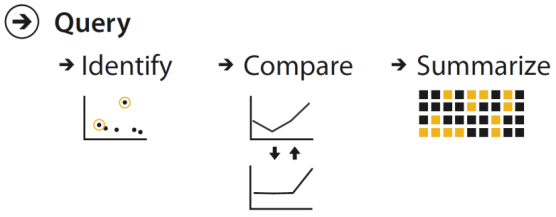
[Development of an information visualization tool using virtual reality. Kirner and Martins. Proc. Symp. Applied Computing 2000]

Visual Information Seeking Mantra

- influential mantra from Shneiderman

  [The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. Shneiderman. Proc. IEEE Visual Languages, pp. 336–343, 1996.]

- overview = summary
  - microcosm of full vis design problem
- nuances
  - beyond just two levels: multi-scale structure
  - difficult when scale huge: give up on overview and browse local neighborhoods?



[Search, Show Context, Expand on Demand: Supporting Large Graph Exploration with Degree-of-Interest. van Ham and Perer. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 953–960.]

Latency of Interaction

- Human reaction to **interaction latency**

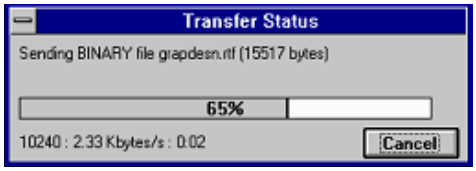
Time Constant	Value (in seconds)
perceptual processing	0.1
immediate response	1
brief tasks	10

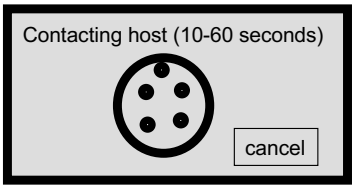
- Visual feedback is necessary
  - As confirmation that the action has completed
  - Progress indicator should be shown if the action takes longer

Latency of Interaction

- Different feedback time scales
  - Shall I wait for that task to finish or go for coffee?

> 10s	User will switch to another task while waiting
10s	Difficult to stay focused
1s	Delay but user's flow of thought is uninterrupted
.1s	Causality





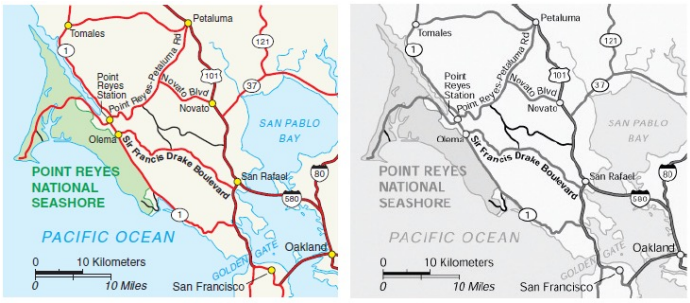
- Different techniques
  - Short transaction: hour glass cursor
  - Longer transaction: estimate of time left
    - An overestimate is always better!

Responsiveness is Required

- Have a good match between the latencies of
  - The low-level interaction mechanism
    - clicking on the item
    - mouse hover with dwell time
    - mouse-over without dwell time
  - The visual feedback mechanism for showing information
    - A fixed view at the side of the screen – no occlusion
    - A popup window
    - A visual highlight change directly in the view
  - The system update time
    - Hard to guarantee immediate response to user in large/distributed datasets

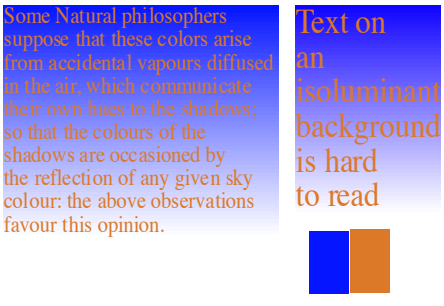
importance of luminance channel

- Ensure that the most crucial aspects are legible in **black and white color**
  - Most important attribute with the luminance channel
  - Hue and saturation as secondary sources



Danger of equal luminance

- **Luminance contrast** needed to see **detail**
  - 3:1 recommended
  - 10:1 ideal for small text
- Equal luminance makes it hard to read despite a large chromatic difference
- Purely chromatic differences are not suitable for displaying fine detail



Some Natural philosophers suppose that these colors arise from accidental vapours diffused in the air, which communicate their own hues to the shadows;

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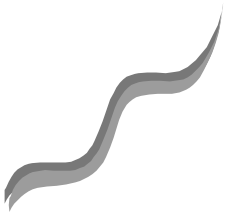
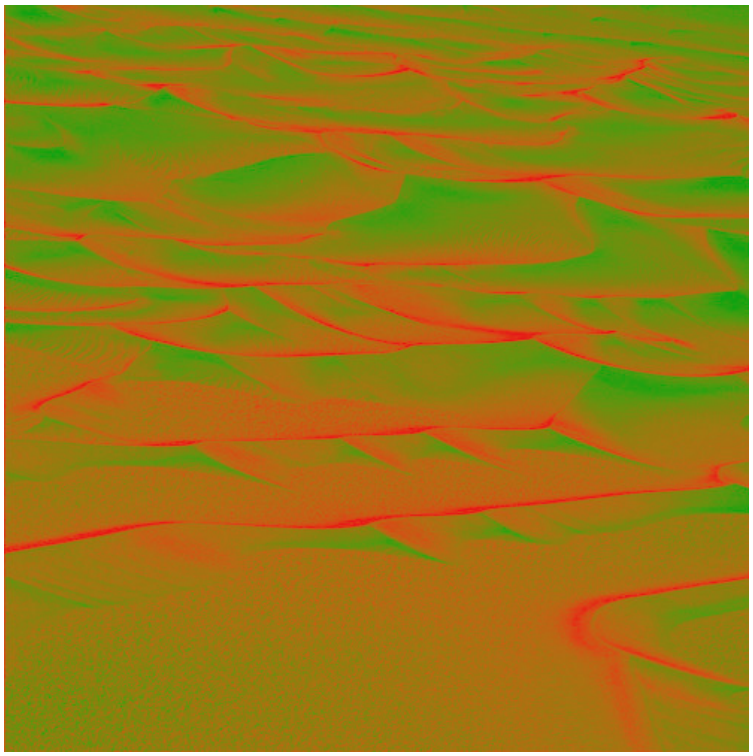
Luminance contrast for revealing detail



In any case
where it is necessary
to reveal fine detail
luminance contrast is
essential

Colin Ware

Shape-from-hue



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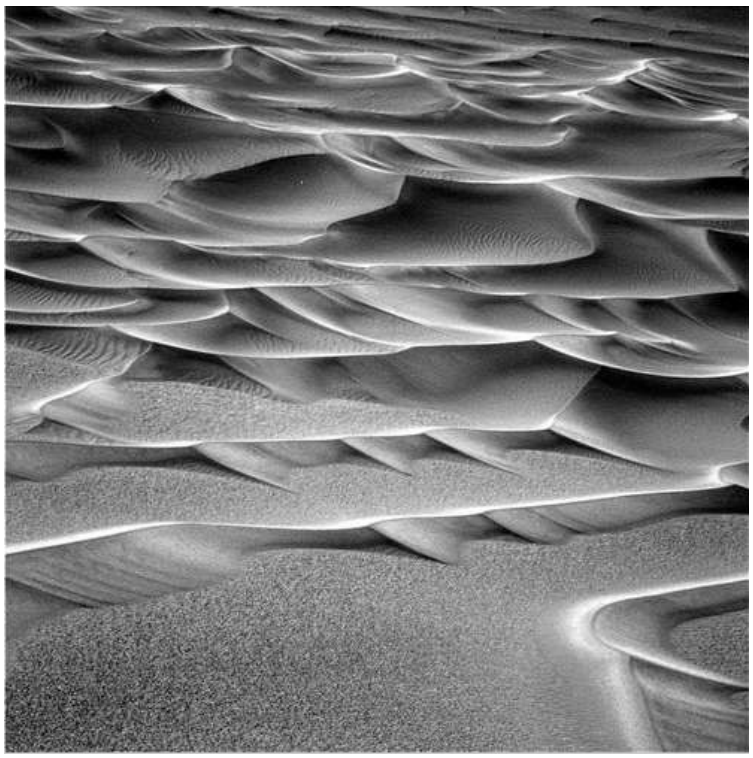
Shape-from-shading



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Function first, form next

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보기 좋은 떡이 먹기도 좋다?

- start with focus on functionality
  - straightforward to improve aesthetics later on, as refinement
  - if no expertise in-house, find good graphic designer to work with
- dangerous to start with aesthetics
  - usually impossible to add function retroactively

Note

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Further reading

- Visualization Analysis and Design. Munzner. AK Peters / CRC Press, Oct 2014.
  - *Chap 6: Rules of Thumb*
- Visual Thinking for Design. Ware. Morgan Kaufmann, 2008.
- Information Visualization: Perception for Design, 3rd edition. Ware. Morgan Kaufmann /Academic Press, 2004.
- *The use of 2-D and 3-D displays for shape understanding versus relative position tasks.* St. John, Cowen, Smallman, and Oonk. Human Factors 43:1 (2001), 79–98.
- *Evaluating Spatial Memory in Two and Three Dimensions.* Cockburn and McKenzie. Intl. Journal of Human-Computer Studies 61:30 (2004), 359–373.
- *Supporting and Exploiting Spatial Memory in User Interfaces.* Scarr, Cockburn, and Gutwin. Foundations and Trends in Human Computer Interaction, 6. Now, 2013.
- *Effectiveness of Animation in Trend Visualization.* Robertson, Fernandez, Fisher, Lee, and Stasko. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis08) 14:6 (2008), 1325–1332.
- *Animation: can it facilitate?* Tversky, Morrison and Betrancourt. Intl Journ Human-Computer Studies, 57(4):247-262, 2002.
- *Current approaches to change blindness.* Simons. Visual Cognition 7:1/2/3 (2000), 1–15.
- The Non-Designer's Design Book, 3rd ed. Williams. Peachpit Press, 2008.

Note

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- Questions?