

Perception

Presented by: Meghan Allen

Papers

- Perceptual and Interpretative Properties of Motion for Information Visualization, Lyn Bartram.
- Internal vs. External Information in Visual Perception. Ronald A. Rensink.
- Level of detail: Varying rendering fidelity by exploiting human change blindness. Kirsten Cater, Alan Chalmers and Colin Dalton.
- Face-based Luminance Matching for Perceptual Colormap Generation. Gordon Kindlmann, Erik Reinhard, and Sarah Creem.
- Large datasets at a glance: Combining Textures and Colors in Scientific Visualization. Christopher G. Healey and James T. Enns.

Perceptual and Interpretative Properties of Motion for Information Visualization

Lyn Bartram

Motivation

- Current interfaces exceed the human's perceptual capacity to interpret them
- Motion is a perceptually rich and efficient display mechanism, but little research has been done to determine how well it can display abstract data

Difficulties in visualizing information

- Large amount of data requires a lot of screen real estate, as well as coordination between multiple windows
- Dynamic nature of data requires users to notice changes
- Some data appears in multiple parts of the visualization system, requiring users to assimilate the 'big picture' in their heads

Graphical representations

- Shape, symbols, size, colour and position are 'mentally economical'
- But, as the amount of data we want to visualize increases and as the size of the screen we are using increases, more attention needs to be paid to improving 'information bandwidth'

Motion

- Can motion be used to encode abstract data?
 - Motion is perceptually efficient and is becoming more technologically practical
 - Visual system is pre-attentively sensitive to motion across the entire visual field
 - Humans can pre-attentively track up to five objects in motion at the same time
 - By nature uses very little extra screen space
 - Can be 'layered' with existing representations to increase the dimensionality

Grouping

- Humans perceive groups when they see multiple object moving in the same manner
 - This could be useful for denoting group membership for objects that are not spatially close
 - Could be useful for temporal as well as spatial groups

Future Directions

- Conducting experiments into simple motion and types of patterns for grouping and association cues
- How can motion convey relationships such as dependency and causality?

Critique

- Interesting idea
- Builds well on information that is known about the human perceptual system

- I am not convinced that motion is a reasonable way of increasing displayed dimensionality.

Internal vs. External Information in Visual Perception

Ronald A. Rensink

Human vision

- We often feel that we must have a strong internal representation of all the objects we can see
- Several experiments have argued against this
- Attention is required to create a 'stable object representation'

Change blindness

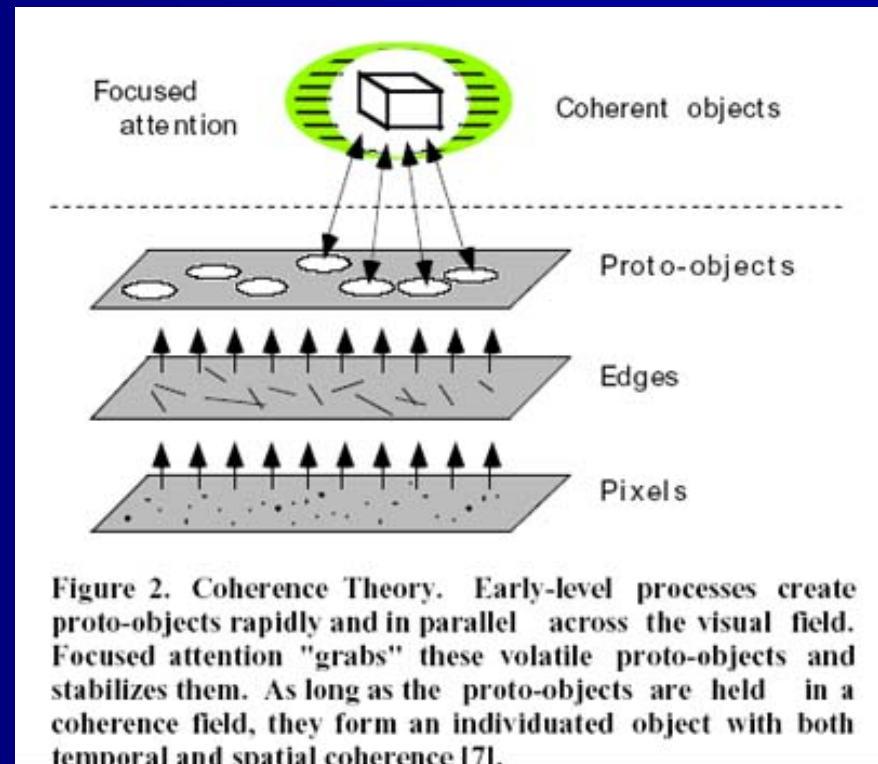
- Subjects have difficulty noticing the changes that are made between the images
- General phenomenon and can be induced many ways
- Examples

Coherence theory

- Low level proto-objects are continually formed, without attention.
- Focused attention selects a small number of proto-objects, based on a feedback loop called a coherence field.
- Proto-objects lose their coherence after focused attention is released.

Coherence theory

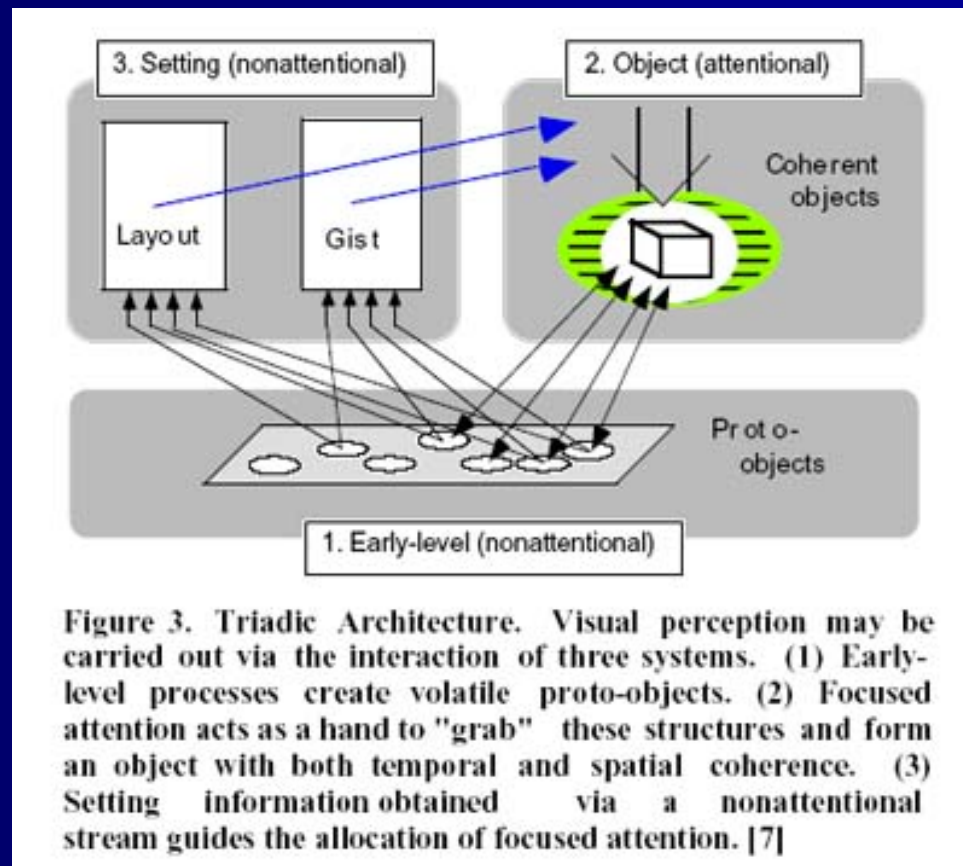
Changes will only be noticed if the objects is being attended at the time



Virtual Representation

- Only create a detailed representation of the object being attended
- If these detailed representations can be created whenever needed, the scene representation will appear “real” to the higher levels, but with huge computational savings

Triadic architecture



Implications for displays

- How can we create visual output that best match the type of information pickup described in coherence theory?
- We can determine the order in which aspects of a scene are attended to, and use that information to select what to render
- There are limits on what the user will perceive, which is important if the change itself was an important part of the visualization

Visual transitions

- Humans may miss transitions, which could be an advantage or a disadvantage
- User interfaces could attempt to take advantage of change blindness so that their transitions were invisible
- Displays should minimize
 - the number of dynamic events occurring in the background
 - the number of saccades

Attentional coercion

- Magicians have been using this for centuries
- By controlling what people are paying attention to you can control what they see
- A coercive display could ensure that important events are seen

Critique

- Good descriptions of the different ways we visually perceive information
- The figured aided my understanding of coherence theory and triadic architecture
- I wanted to read about some real examples of coercive displays

Level of detail: Varying rendering fidelity
by exploiting human change blindness.

Kirsten Cater, Alan Chalmers and Colin
Dalton

Motivation

- Most virtual reality environments are too complex to be rendered in real time
- Change blindness can be exploited to shorten rendering times without compromising perceived quality

Change blindness

- 'the inability of the human eye to detect what should be obvious changes'
- If attention is not focused on an object in a scene, changes to that object may go unnoticed
- Occurs because our internal representation of the visual world is sparse and only contains objects of interest

Visual Attention

- Spatial acuity is highest at the centre of the retina, the fovea
- Visual angle covered by the fovea is approximately 2 degrees
 - Saccade: moving the next relevant object into the focus of the fovea

Background

- O'Regan et al.'s flicker paradigm, and mudsplash paradigm
 - Marginal interest vs. Central interest
- Peripheral Vision
 - Human eye only processes detailed information from a small part of the visual field

Experiment

- 24 images, aspects of the images were labeled Central interest or Marginal interest
- Principles of the flicker and mudsplash paradigms were used, but the image was rendered differently each time instead of using photographs

Experiment

- Rendering quality was a factor
 - High resolution images took approximately 18 hours to render
 - Low resolution images took approximately 1 minute to render

Results

- Subjects took significant amounts of time to notice the changes in the images
- Modified central interest aspects were found faster than modified marginal interest aspects
- Subjects were much slower to recognize rendering changes compared to location or presence changes

Conclusions

- Computational savings could be dramatic
- Inattentional blindness is the failure to see any unattended objects

Critique

- 'Change Blindness occurs in computer graphics images as it does in real life' – seemed obvious to me
- Didn't give any specific guidelines on how to exploit Change Blindness in software applications

Face-based Luminance Matching for Perceptual Colormap Generation.

Gordon Kindlmann, Erik Reinhard, and
Sarah Creem

Luminance

- Luminance is a very important aspect of visualization because it affects our perception of image structure and surface shape
- 3 issues with using luminance in colormaps
 - Uncalibrated displays
 - Lighting conditions of the room are unknown
 - Yellow pigments can cause non-trivial differences

Luminance efficiency function

- Describes the sensitivity of the eye to various wavelengths
- Many of the techniques to measure the luminance efficiency function are based on matching
- Goal is to create a task similar to the minimally distinct border method that is easier for users

Method

- One face appears 'positive' while the other appears 'negative'
- Black is replaced by gray and white is replaced by a colour



Figure 1: Double face image

Example

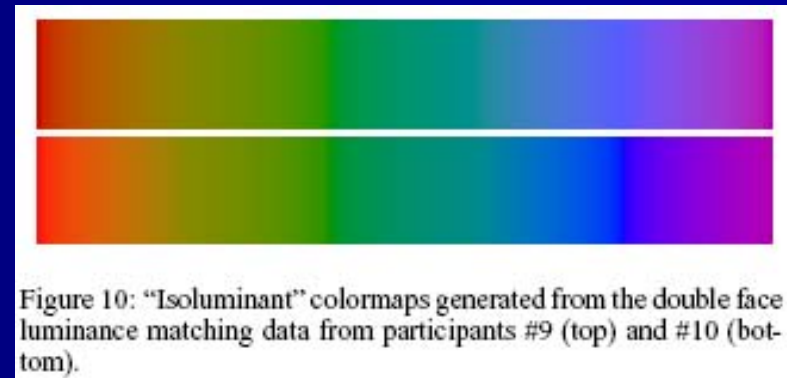


User study

- Compared MDB to face based luminance matching
- No significant difference by task, but face based luminance matching was more precise than MDB

Colormap generation

- Need to create the hues in between the 6 that were matched by interpolation
- Used data from the user study averaged over all participants and trials



Critique

- Interesting idea
- Succinctly explained the background information and related work
- Well designed user study, with good hypotheses

Large datasets at a glance: Combining Textures and Colors in Scientific Visualization.

Christopher G. Healey and James T. Enns

Objective

- To create a method to display complex and large data sets that encode multiple dimensions on a single spatial point

Example

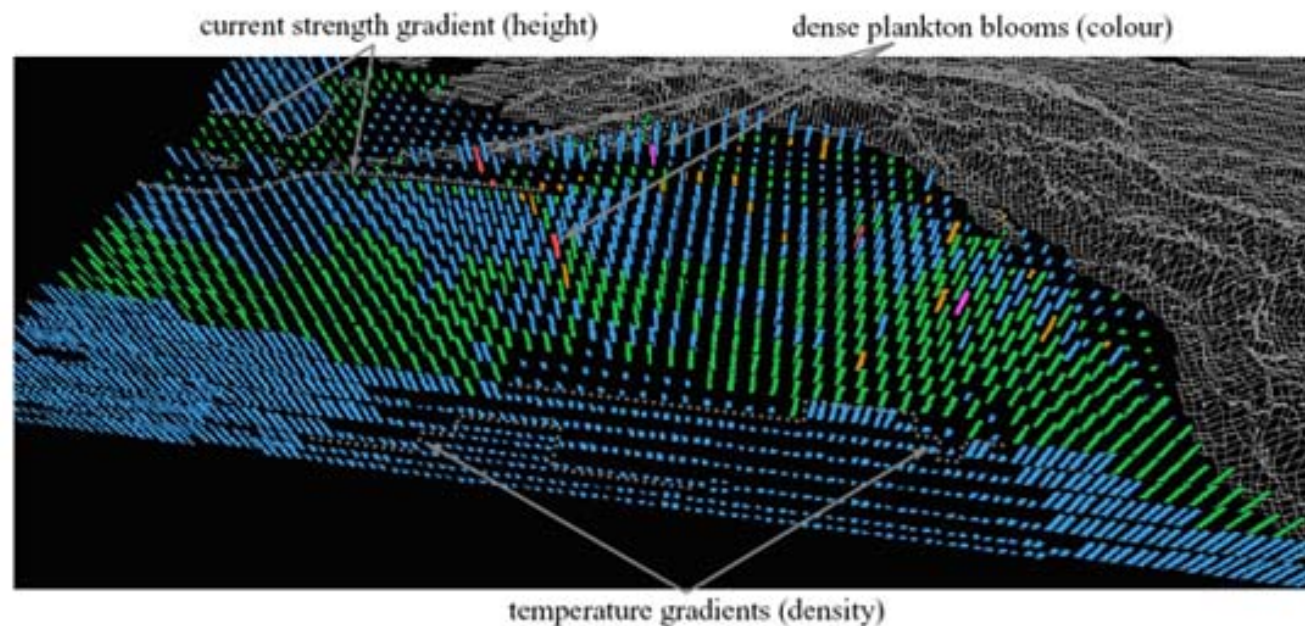


Fig. 1. Color, height, and density used to visualize open-ocean plankton density, ocean current strength, and sea surface temperature, respectively; low to high plankton densities represented with blue, green, brown, red, and purple, stronger currents represented with taller pixels, and warmer temperatures represented with denser pixels

Bottom up vs. top down

- Bottom up: the limited set of features that psychologists have identified as being preattentive
- Top down: attention is controlled by the task you are attempting to perform

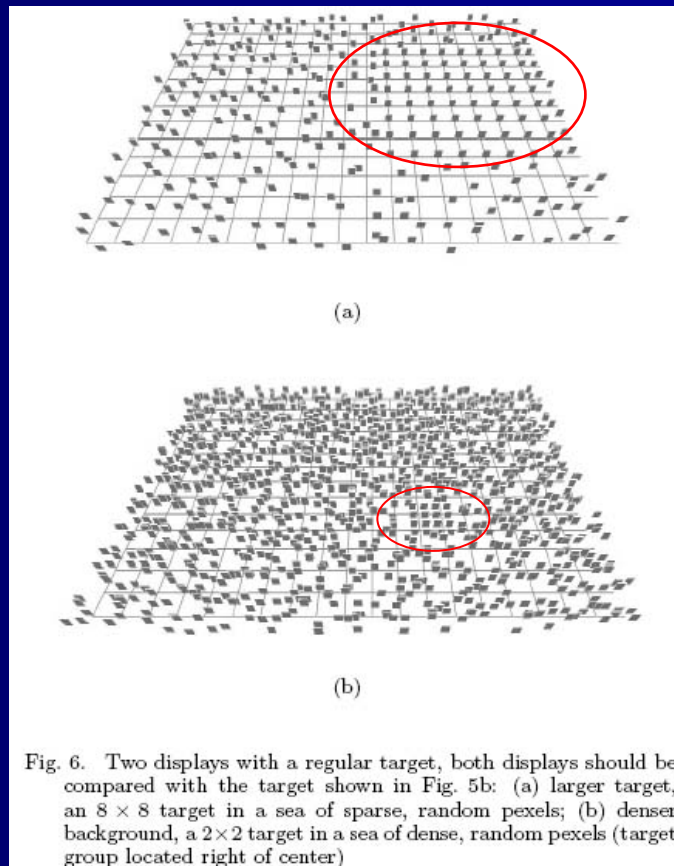
Pexels

- Multicolored perceptual texture elements (pexels) are used
- Pexels have differing height, density, regularity and color
- Goal: select texture and color properties that allow for fast visual exploration, while minimizing interactions between the visual features

Experiments

- Can density, regularity and height be used to show structure?
- How can we use the dataset's attributes to control the values of each perceptual dimension?
- How much visual interference occurs between the perceptual dimensions?

Example



Results

- Taller regions were identified very quickly
- Shorter, denser, and sparser targets were more difficult to identify than taller targets, although some good results were still found
- Background variation produced small, but statistically significant interaction effects

Results

- Irregular targets were difficult to identify
- Poor detection results for regularity were unexpected

Perceptual Colors

- Designed experiments to select a set of n colors such that
 - Any color can be detected preattentively
 - Every color is equally easy to identify
- Tested for the maximum number of colors that can be displayed simultaneously while satisfying the above requirements

Color

- Color distance
 - Colors that are linearly separable from one another are easier to distinguish
- Color category
 - Colors that are in different named categories (such as purple and blue) are easier to distinguish

Experiment

- First experiment controlled color distance and linear separation but not color category
- 4 studies that displayed 3, 5, 7 and 9 colors simultaneously

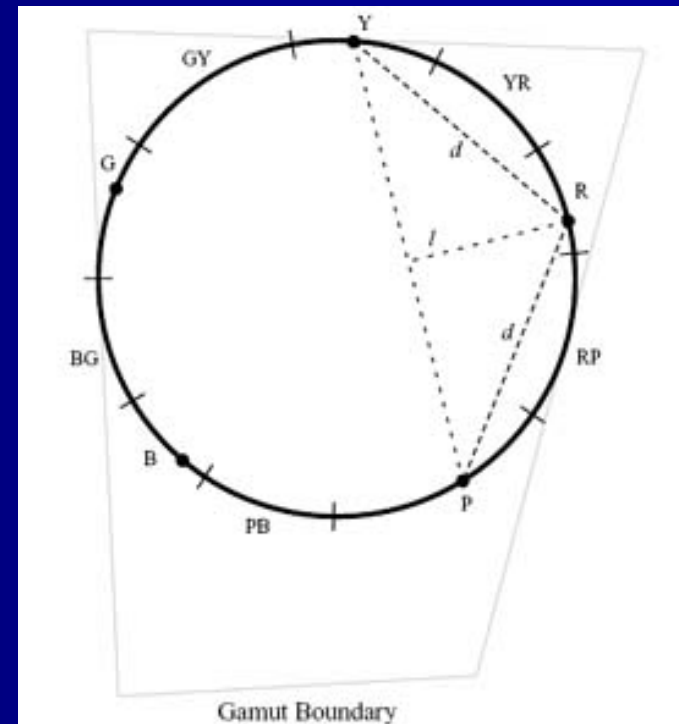


Fig. 9. Choosing colors from the monitor's gamut, the boundary of the gamut at $L^* = 61.7$ represented as a quadrilateral, along with the maximum inscribed circle centered at $(L^*, u^*, v^*) = (67.1, 13.1, -0.98)$, radius $70.5\Delta E^*$; five colors chosen around the circle's circumference; each element has a constant color distance d with its two neighbors, and a constant linear separation l from the remaining (non-target) elements; the circle's circumference has been subdivided into ten named categories, corresponding to the ten hue names from the Munsell color model

Results

- All targets were detected rapidly and accurately when 3 and 5 colors were displayed
- With 7 and 9 colors, the time to detect certain colors was proportional to the display size
- Is this due to color categories?

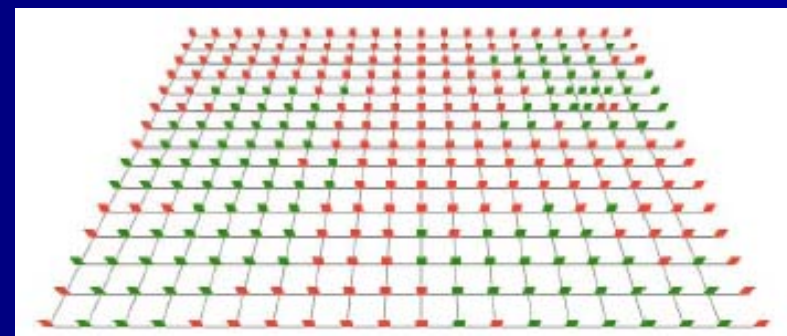
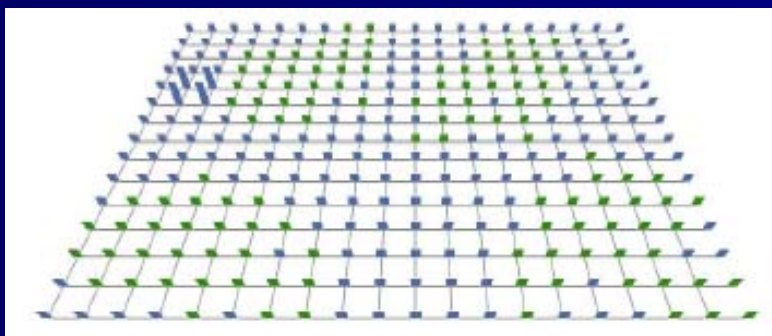
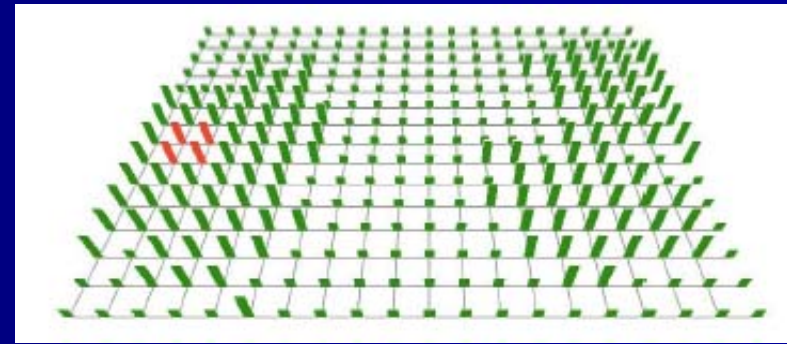
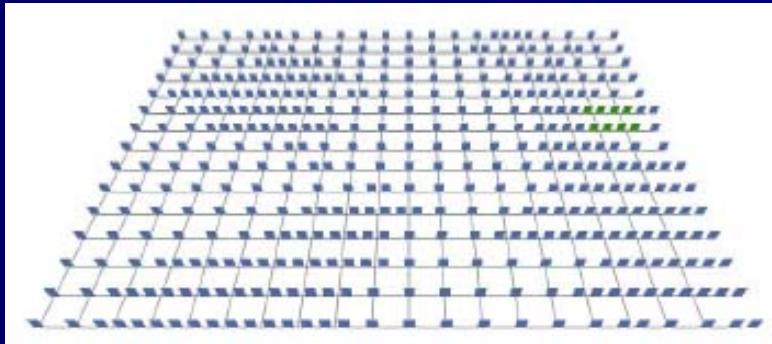
Color category experiment

- Subjects were asked to describe colors
- The amount of overlap between the names was used to determine 'category overlap'
- Category overlap was a good indicator of performance

Texture and Color

- Do variations in pixel color affect the detection of targets defined by height or density?
- Do variations in pixel height or density affect the detection of targets defined by color?

Examples



Results

- Background variation had no effect on detection of color targets.
- Detection accuracy for height and density targets was similar to results from the texture experiments
- Background variation in color had a small but statistically significant effect
- Denser and taller targets were easier to recognize

Practical applications

- Visualizing typhoons
 - Windspeed (height)
 - Pressure (density)
 - Precipitation (color)

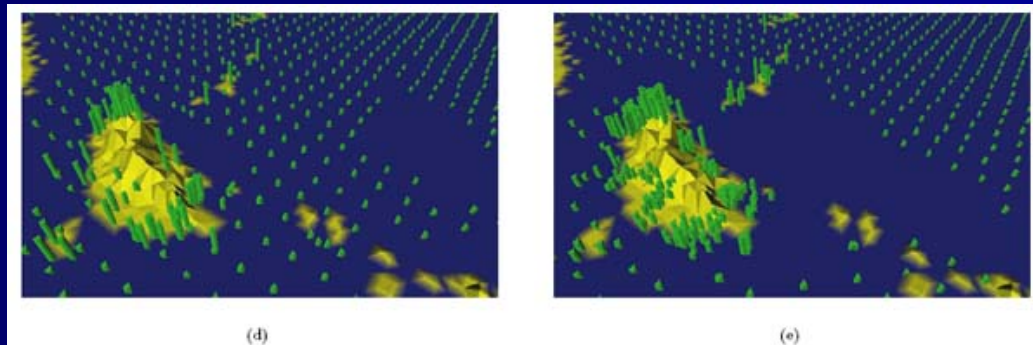


Fig. 14. Typhoon conditions across Southeast Asia during the summer of 1997: (a) August 7, 1997, normal weather conditions over Japan; (b) August 27, 1997, typhoon Amber approaches the island of Taiwan from the southeast; (c) August 28, 1997, typhoon Amber strikes Taiwan, producing tall, dense pixels colored orange, red, and purple (representing high precipitation); (d, e) the same data as in (b) and (c) but with windspeed represented by regularity, pressure by height, and precipitation by density

Conclusions

- Data/feature mapping must match with the workings of the human visual system
- Color distance, linear separation and color category must all be considered when choosing colors
- Results were validated when applied to real world data

Critique

- Thorough experiments
- Pexels only allow 3 dimensions to be displayed
- No guidelines about how to map your data to the representations

Bibliography

- Internal vs. External Information in Visual Perception. Ronald A. Rensink. Proc 2nd Int. Symposium on Smart Graphics, pp 63-70, 2002
- Large datasets at a glance: Combining Textures and Colors in Scientific Visualization. Christopher G. Healey and James T. Enns. IEEE Transactions on Visualization and Computer Graphics 5, 2, (1999), 145-167.
- Face-based Luminance Matching for Perceptual Colormap Generation. Gordon Kindlmann, Erik Reinhard, and Sarah Creem. Proc. Vis 2002.
- Perceptual and Interpretative Properties of Motion for Information Visualization, Lyn Bartram, Proceedings of the 1997 workshop on New paradigms in information visualization and manipulation, 1997, pp 3-7
- Level of detail: Varying rendering fidelity by exploiting human change blindness. Kirsten Cater, Alan Chalmers and Colin Dalton. Proceedings of the 1st international conference on Computer graphics and interactive techniques in Australia and South East Asia, 2003, pp 39-46