CSE 591: Visual Analytics

Lecture 1: Introduction

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With some material from Robert Kosara, UNCC, and Daniel Keim, U Konstanz

The Goal of Visualization

Ease understanding of the data by providing an effective visual representation

Amplify Perception

Detect the Expected, Discover the Unexpected™

What is Visual Analytics

Visualization plus…

- interaction
- data processing
- story telling
- scientific approach

Visual Analytics is the science of analytical reasoning supported by a highly interactive visual interface

Intelligence Analysis

Intelligence analysis is challenging

Huge amounts of data

Low signal vs. noise

Many data types

- text, images, video, sensor data, etc.

Uncertainty

Contradictions

Omissions

Use of Visualization

Visual perception

- high bandwidth
- fast screening of a lot of data
- pattern recognition
- higher-level cognition

Interaction

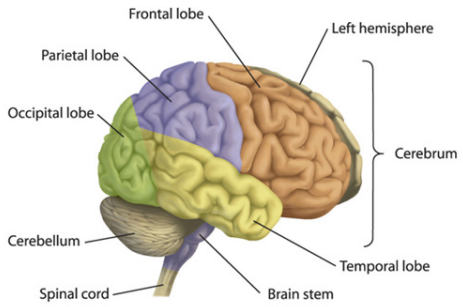
- direct manipulation
- two-way communication

Let us have a closer look at the human visual system…

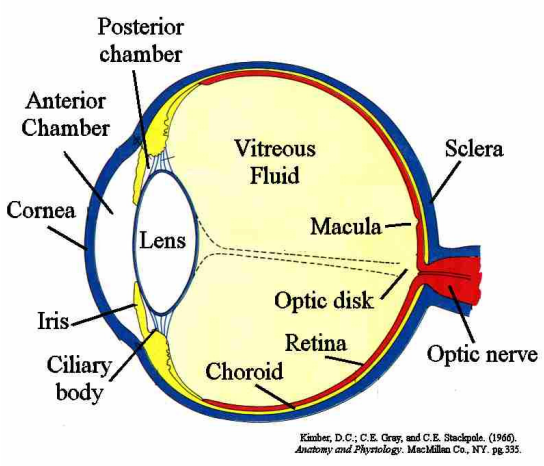
The Visual Brain

Over 50% of the human brain is dedicated to vision and visual representations,

- decoding visual information
- high-level processing of visual information
- thinking with visual metaphors



Input Device: The Eye



Sensor: The Cones and Rods

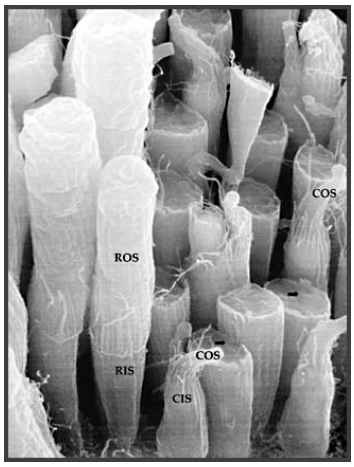
Two types of receptors on retina:
rods and *cones*

Rods:

- spread all over the retinal surface (75 - 150 million)
- low resolution, no color vision, but very sensitive to low light (*scotopic* or dim-light vision)

Cones:

- a dense array around the central portion of the retina, the fovea centralis (6 - 7 million)
- high-resolution, color vision, but require brighter light (*photopic* or bright-light vision)



Wiring: The Visual Pathways

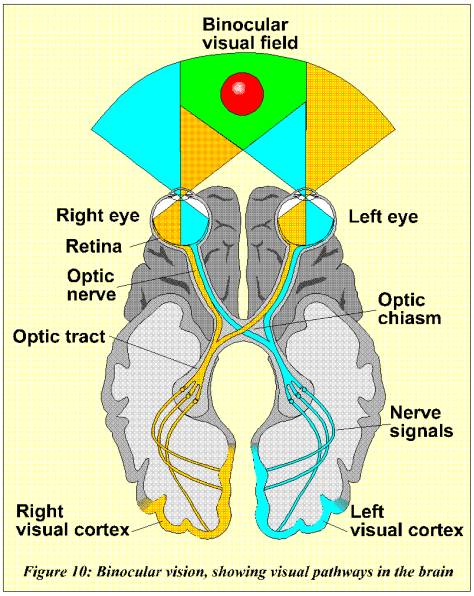
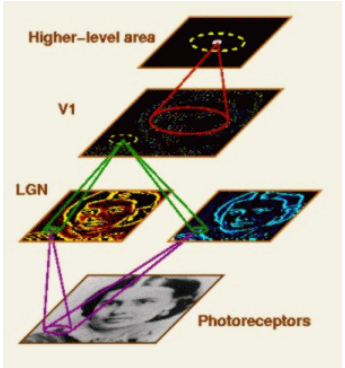


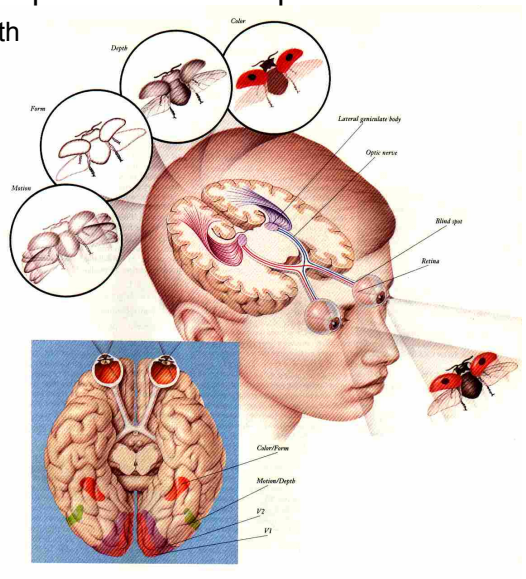
Figure 10: Binocular vision, showing visual pathways in the brain

Processing Unit: The Visual Cortex (V1, V2)

Visual cortex breaks input up into different aspects:

- color, shape, motion, depth



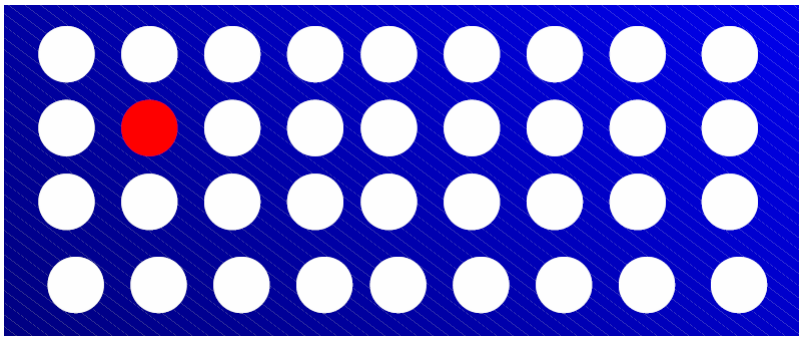


LGN= Lateral Geniculate Nucleus

Pre-Attentive Processing

If you want it or not: some features are always detected

And fast – within 200 ms or less



Pre-Attentive Processing

Why is it so fast?

Well, because 50% of the brain is dedicated to vision

Vision is a MASSIVELY parallel processor dedicated to

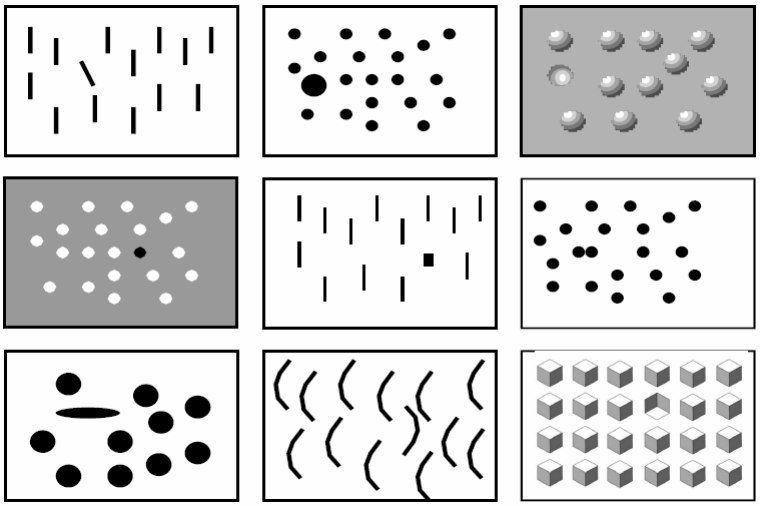
- detect
- analyze
- recognize
- reason with

visual input

Pre-Attentive Processing

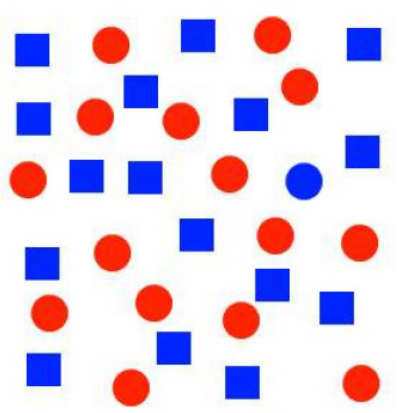
Sensitivity to differences in:

- color, orientation, size, shape, motion, shading, 3D depth, …



Pre-Attentive Processing

But there are limits: conjunctions don't work well



quick: find the blue circle

Pre-Attentive Processing

Some features/cues are stronger than others:

Look at the chart and say the COLOUR not the word

YELLOW BLUE ORANGE
BLACK RED GREEN
PURPLE YELLOW RED
ORANGE GREEN BLACK
BLUE RED PURPLE
GREEN BLUE ORANGE

Left – Right Conflict
Your right brain tries to say the colour but your left brain insists on reading the word.

Pre-Attentive Processing

Words are patterns, which form strong pre-attentive feature

- this would have been different if this had been done in Arabic

There are limits, however

- let's see the next experiment

Pre-Attentive Processing

Reading 1

Aoccdrnig to a rscheearch at an Elingsh uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht frist and lsat ltteer is at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae we do not raed ervey lteter by it slef but the wrod as a wlohe

Pre-Attentive Processing

Now, is tihs ture? Raed on….

Pre-Attentive Processing

Reading 2

Anidroccg to crad cniyrrag lcitsiugnis planoissefors at an uemannd, utisreviny in Bsitirh Cibmuloa, and crartnoy to the duoibus cmials of the ueticnd rcraeseh, a slpmie, macinahcel ioisrevnn of ianretnl cretcarahs araepps sneiciffut to csufnoe the eadyrevy oekoolnr

Pre-Attentive Processing

Reading 2

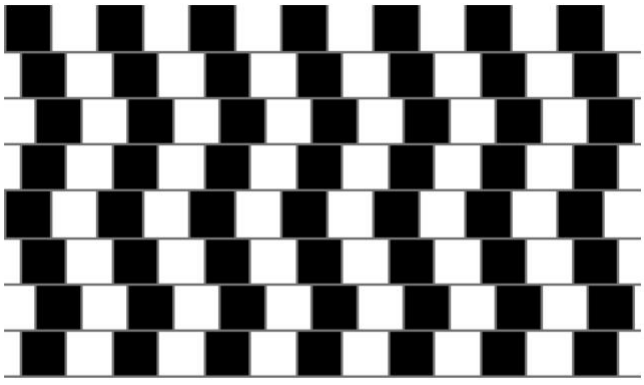
According to card carrying linguistics professionals at an unnamed, university in British Columbia, and contrary to the dubious claims of the uncited research, a slpmie, macinahcel ioisrevnn of ianretnl cretcarahs araepps sneiciffut to csufnoe the eadyrevy oekoolnr

Pre-Attentive Processing

Reading 2

According to card carrying linguistics professionals at an unnamed, university in British Columbia, and contrary to the dubious claims of the uncited research, a simple, mechanical inversion of internal characters appears sufficient to confuse the everyday onlooker

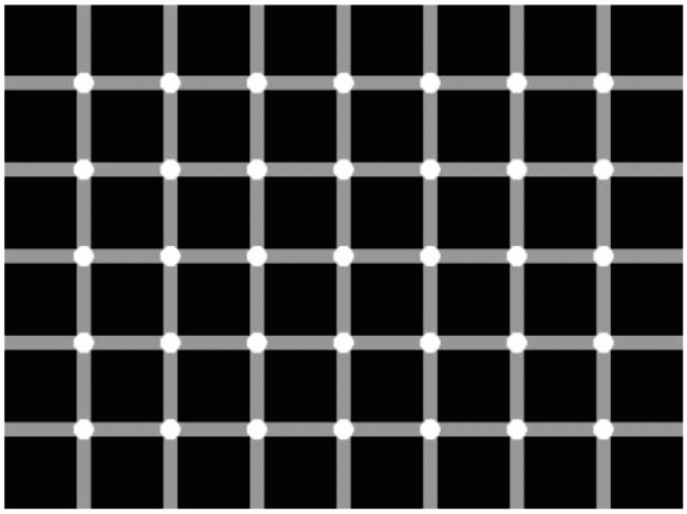
Fooling the Visual System: Optical Illusions



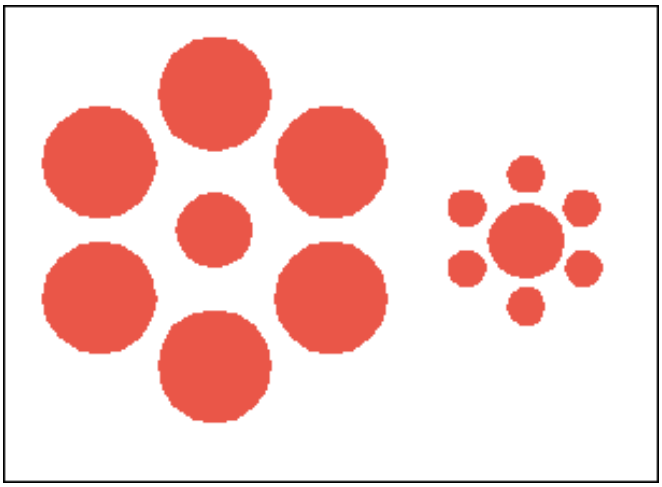
Are the horizontal lines parallel or do they slope?

Fooling the Visual System: Optical Illusions

Count the black dots!

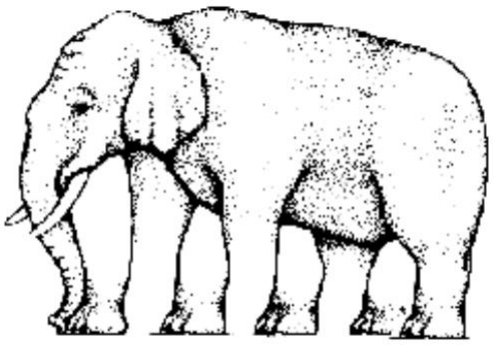


Fooling the Visual System: Optical Illusions



Which circle in the middle is bigger?

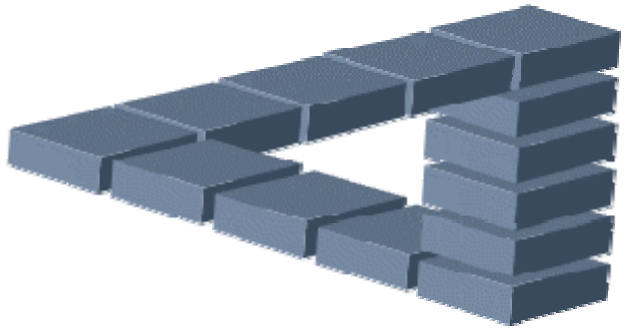
Consistency: Local vs. Global



How many legs does this elephant have?

Consistency: Local vs. Global

Consistency: Local vs. Global



View Point

Julian Beever

View Point

Julian Beever

View Point

Julian Beever

Focus vs. Periphery

Humans tend to overlook/ignore non-focus (and unexpected) objects even when very close and obvious

- see various experiments by Daniel Simons, UIUC
- Visual Analytics slogan: *Detect the Unexpected*

Humans also have limited working memory

- fine details are quickly forgotten when focus changes
- big effect in animated or interactive visualizations
- need to preserve temporal context

Explosion of Data

82,000 fingerprints are matched every day against INS database with 40 million records

100 million VISA credit card transactions per day

300 million phone long distance calls on ATT's network per day

7 million IP packets per second on DE-CIX backbone

→ there is *NO* chance to visualize all these data

The Sense-Making Loop

Support visualization with computations for data processing

Form a loop: visualize - refine

Gather (forage) information

Re-Represent

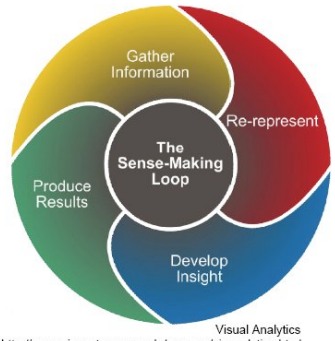
- choose form that aids analysis

Develop insight

- through manipulation of representations

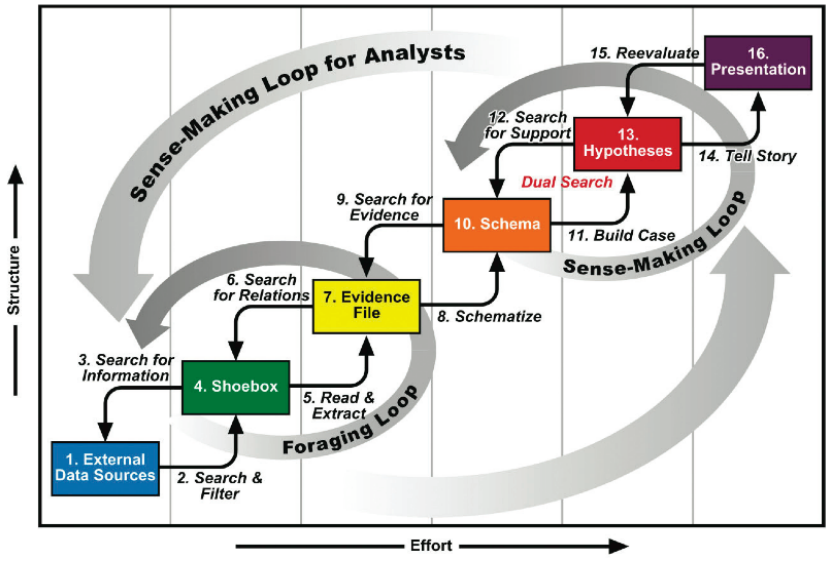
Produce results

- "product"



Visual Analytics
http://www.viscenter.uncc.edu/courses/visanalytics.html

Nominal Sense-Making Process



Reasoning Artifacts

Elemental artifacts
- source intelligence, evidence, assumptions

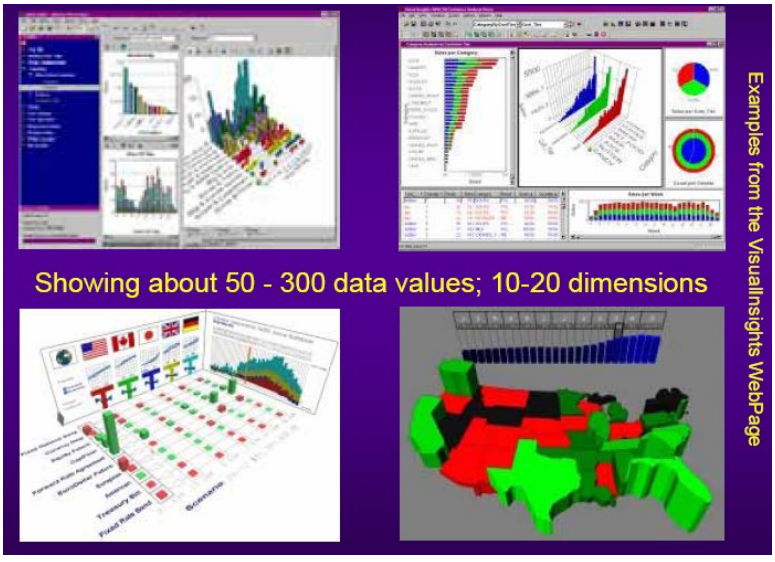
• Pattern artifacts
- relationships, temporal and spatial structure

• Higher-order knowledge constructs
- arguments, causality, models

• Complex reasoning constructs
- hypotheses, scenarios

All these become part of the Visual Analytics sense-making (reasoning) process

Standard Information Displays



Problems With Scalability

Must be scalable to

- number of data points
- number of dimensions
- data sources
- diversity of data sources
- number of users
- diversity of users and tasks
- quality of the data

Let's have a look at more advanced information displays…