September 13th, 2018

LECTURE 3
PATTERNS, PERCEPTION

Recapitulation Lecture 2

- Model Human Processor, STM and LTM
- Closure, User Attitude and Anxiety
- Control
- Emotion & Affect

Key concepts for Interaction Applications so far:
Usability
Cognetics
Q: What is the current population size of the US?

Average heat-map eye-tracking
Specific user categories

- A, D Search dominant (57% of users)
- B Navigation dominant
- C Tool dominant

Distraction from focus ...

- 14% looked at right position
- Majority did not find correct answer.
- Distraction, some parts of the URL looked like an add.
- Can further analyze the users
- !! Simple Usability Question

- Look at direction of each/exploration
Semantic network → Relations
What do you read ...

TAE CAT

• Information processing to Meaningful items from Context
• Prior Knowledge helps processing ambiguous information
• Not: “tae cht”, But: “the cat”

REASONING
Reasoning (1)

• Deductive reasoning
  – Derive logically necessary conclusion from given premises.
    • If it is Monday then she will go to class
      It is Monday. Therefore she will go to class
  – Conflict in logic
    • If it is raining then the ground is dry
      It is raining. Therefore the ground is dry
  – Prior knowledge is addressed to solve conflicts

• Abductive reasoning
  – reasoning from event to cause
    • Students drink beer when preparing a test
      If I see Students drinking, I assume them preparing.

• Unreliable:
  – can lead to false explanations

Reasoning (2)

• Inductive reasoning
  – Starts from an Induction
  – Generalize from cases seen to cases unseen
    all elephants we have seen have trunks
    therefore all elephants have trunks.

• Unreliable, ... but useful!
  – can only prove false not true
Learning strategies

• Behaviorism
  – Measurement of outcome of learning process
  – Not considering the mental process
  – Behavior modified by reinforcement responses

• Gestalt
  – Past experience affects individual perception
  – Stimuli grouped in own perception patterns
  – Processes leave a trace in the brain (encoding)
  – Group information to make it more meaningful

PERCEPTION
### Perception – what is it ...

- **Webster (definitions)**
  - the way that you notice or understand something using one of your senses
  - awareness of the elements of environment through physical **sensation**

- **2 Elements**
  - Physical sensing of a signal
  - Cognitive concience interpretation of a signal

### Overview Gestalt

- **Gestalt = Pattern/Form/Shape**
- **Gestalt helps ordering a scene (signal)**
  - Pragnanz
  - Proximity
  - Similarity
  - Closure (different from previous use of term)
  - Good continuation
  - Common fate
  - Familiarity
- **Gestalt is a bottom-up approach (stimulus-perception)**
- **Principles are being used in Symbol design**
  - Icons
  - Easterby, 1970
### Image - Pattern

- **Figure**
  - That what is the important subject
  - Foreground

- **Ground**
  - That what is the environment of the subject
  - Background

- **We actively separate Figure from Ground**
  - Selecting what is important

### Pragnanz

- Patterns are seen as simply as possible
Proximity

• Nearby objects tend to be grouped together

Similarity

• Similar items tend to be grouped together
• Tendency to group elements of same shape or color as belonging together
Closure

- Nearly closed contours tend to be closed
- Missing parts are filled in ...

Continuity

- Neighbors are grouped when they can be connected
- Simplifying a stimulus
Constructivists ~ Ecologists

We are active in our perception:

- **Constructivists approach for vision**
  - Perception involves intervention of representation and memory
  - Actively embellish (process) and elaborate retinal images (stimuli)
  - Related to Gestalt (1935): interpretation result from having innate laws of organization

- **Ecological approach for vision**
  - Active exploration of objects in environment (Gibson)
  - Use of 5 senses
  - Notion of affordances; easy/difficult to interact with object

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Using Gestalt in GUI: proximity

Not used

Used

Used
Using Gestalt in GUI: Similarity

Organization of files in a folder (GUI).

Gestalt in Design: Pragnanz

- Prominent role of the figure with respect to figure-ground
- Logo makers use this effect.
- See examples of 3 logos.
- Figure and ground can not be observed at the same time.
- Interpretation!!!

![Mac Logo](image1.png)
![GNOME Logo](image2.png)
![Norway Logo](image3.png)
Gestalt in Design: Closure

- We see more than actually is presented.
- We produce a closure to known artifacts

Website Design - Gestalt

Common Fate
Crux of Human Vision

Facts:
• We like to see “whole” rather than “part”
• There is prior knowledge (LTM)
• There is interpretation ~ cognition
• Gestalt uses the fact that the sum is more than the separate parts

These facts are unconsciously used in GUI design
Make yourselves aware!
What do you see...

What meets the eye!

Human Vision – Visual System

What meets the eye!
Photo-sensors: the Retina

- From eye to retina to visual cortex: electrical pulses
- Cones
  - 6-7 *10^6 per eye
  - One cone-cell connected to one nerve
  - Photopic vision (bright-light vision)
- Rods
  - 75-150 *10^6 per eye
  - Several rods connected to one nerve
  - Scotopic vision (dim-light vision)
- Distribution of sensors is important for vision
- Distribution is radial symmetric around Fovea

Cones and Rods

From Atlas of Histology, University of Illinois
Aspects of Human Vision

Distribution of Rods and Cones in the Human Retina

Visual Field

Visual Field:
- (a) Sharp vision
- (b) Un-sharp vision
- (c) Only movement seen

Retinal Image:
- Reflected in fovea area
- Eye muscles help project in fovea area
**Color Perception in Human**

- **Fovea centralis**
  - Very detailed colour vision
  - 1 degree of visual field
- Colour sensitivity of 3 types of cones
  - A - mostly red,
  - B - mostly green,
  - C - mostly blue
- Eye most sensitive to green/yellow
- Eye least sensitive to blue

**Cone Sensitivity to Light**

- 3 Types of Cones & Light of equal Intensity
Color Perception in Human

- Complex perceptual system
  - Cone response e.g.
    - 17:44:39 is blue,
    - 61:39:0 is yellow,
    - 50:45:5 is white

- Defective colour vision
  - 8% males, 0.5% females
  - Red/green blindness is most common

Color Impairment, Red ~ Green

- X-chromosome related
- Males (XY)
- Female (XX)
- Deficiency more common in males
- 5-8% males
- 0.5% females
**Color Blind**

- Normal
- Protans — (red weak)
- Deutans — (green weak)

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**Elements of Color Perception**

- There are 3 elements to color perception
  - **Hue**, perception to a color name, i.e. a spectral definition
  - **Saturation**, intensity of a color, with a reference to black and white
  - **Lightness** — (value), reflection of a color from a surface with reference to nearby surfaces

- This is part of a color model on perception, more on this in the color lecture
Perceptual Processing of Vision

- Vision consists of sub-systems
- Framework for perceptual vision
  - 2-3 stages
  - Helps understanding perception
- Stage 1
- Stage 2
- Stage 3

Simple Model (2 stages)
Extended Model (3 stages)

Stage 1 – pre-attentive processing

- Framework for perception
  - Stage 1, Pre-attentive vision
    - There is no focus attention required
    - Resolves in 200-250 msec
    - Basic features in environment, Saliency (remarkable)
    - Bottom-up

  - Pre-attentive vision
    - Parallel low-level vision system
    - Target detection, Boundary detection, Counting
Stage 2 – attribute attention

- Framework for perception
  - Stage 2, Attribute vision
    - There is focus attention required
    - Top-down processing
    - Segment visual scene (color, texture, motion etc.)
  - Attribute vision
    - Slow serial processing
    - Working Memory – Long Term Memory
    - Focus on arbitrary aspects of symbols

Stage 3 – active processing

- Framework for perception
  - Stage 3, Active vision
    - There is focus attention required
    - Top-down processing
    - Reduce to few objects in Visual Working Memory
  - Active vision
    - Slow serial processing
    - Working Memory – Long Term Memory
    - VISUAL THINKING, making inferences i.e. Visual queries
Is there a red circle present (1)

- Hue based
- Rapid – pre-attentive vision
- Surrounding objects: “distractors”

Is there a red circle present (2)

- Shape based
- Rapid – pre-attentive vision
- Surrounding objects: “distractors”
Is there a red circle present (2)

Conjunction of features – Hue and Shape
Can not be completed though pre-attentive vision
Sequential search – typical stage 2, 3

Boundary in complex scene (1)

Conjunction of features – Fill and Shape
Left: Preattentive vision Right: not preattentive vision
Sequential search – typical stage 2, 3
Boundary in complex scene (2)

Conjunction of features – Hue and Shape
Left: Preattentive vision  Right: not preattentive vision (mixing)
Sequential search – typical stage 2, 3

Boundary in complex scene (3)

Conjunction of features – Hue and Brightness
Left: not Preattentive (Interference)  Right: preattentive
Sequential search – typical stage 2, 3
Depth Vision

- Stereoscopy, binocular vision
- Motion parallax,
  - distant objects are slower
- Accommodation,
  - lens focuses at different depths
- Occlusion,
  - close occludes distant
- Texture,
  - distant objects blurry texture
- Familiarity,
  - size and shape of objects
- Laws of perspective
- Shadow casts

Depth Cues

- Humans use eight (8) depth cues

- Depth cues are used by the brain to estimate the relative distance of the objects in every scene we look at.

- Depth cues are very useful in visualization and can be used effectively in InfoVis.

Some examples…
Focus

Wood anemone, by Håkan Dahlström (flickr.com)

Perspective

Tay Rail Bridge, by Colin Broug (sxc.hu)
Occlusion

Diamond Ring, By Mucahid Zengin (flickr.com)

Color Intensity & Contrast

Highland view, by Colin Broug (sxc.hu)
Motion Parallax

Differential motion parallax from infovis.net

Human Audio – Hearing System

Ear detects sound, Brain interprets sound
### Hearing & Auditory perception

- **Hearing:** processing of air pressure variation
  - Density
  - Wave patterns

- **Audition:** extraction of meaning in a pattern
  - Understanding a sound

- **Principles of Gestalt apply**
  - Sonic Gestalt

### Sound Perception in Human

- **Sound is measured**
  - by pitch (frequency, Hz)
  - and loudness (decibels, dB)

- Most people detect sound in the ranges \([20-20 \times 10^3]\) Hz
- Loudness in \([20-70]\) dB constitutes comfortable hearing

- **Features:**
  - Sound is transient,
    - once it is stopped, it does not persist
  - Sound is pervasive
    - we do not have to face it in order to hear it
  - Sound triggers “locus of attention”
### Examples of Sound

- **Loud rock band**: 160 dB
- **Shouting**: 100 dB
- **Conversation**: 50 dB
- **Whisper**: 20 dB

- **Hearing impaired**
  - Middle ear deafness (age & gender)
  - Inner ear deafness

"Hearing is a form of touch. I hear it through the body, by opening myself up. Sometimes it almost hits you in the face."
- Evelyn Glennie
Haptic System

Haptic system is defined as [Gibson]:

- The sensibility of the individual to the world adjacent to her/his body by use of his body.

Haptic perception:
- Links to body movement
- Active exploration.

Human Touch – Haptic System

- Ubiquitous in the body
  - Somatosensory perception of patterns on skin surface
    - edges,
    - curvature,
    - texture
  - Proprioception of position and information.

- Hands are often used for haptics
  - Haptic I/O devices
- Explore other areas
### Key concepts in haptics (1)

- **Proprioceptive** - Relating to sensory information about the state of the body (including cutaneous, kinaesthetic and vestibular sensations).

- **Vestibular** - Pertaining to the perception of head position, acceleration and de-acceleration.

- **Kinaesthetic** - The feeling of motion. Relating to sensations originating in muscles, tendons and joints.

### Key concepts in haptics (2)

- **Cutaneous** - Pertaining to the skin itself or the skin as a sense organ. Includes sensation of pressure, temperature and pain.

- **Tactile** - Pertaining to the cutaneous sense but more specifically the sensation of pressure rather than temperature or pain.

- **Force feedback** - Relating to the mechanical production of information sensed by the human kinaesthetic system.
Directions in Haptics

- Haptic system: bi-directional (in-output)
- Understand touch
- What does one feel/touch
  - Real subject
  - Virtual subject
  - Decouple sense and force
- Internet Interface
- Gaming experience

Example 1

- Adding touch to the iPhone 6s
- More force, more (other) options
- Augments the interaction repertoire
- Haptics is a 2-way interaction
  - Apply force
  - Expect feedback of the force ...
- Success?
  - Is Meaning and Action Coupled?
  - Advertised as Multi-Touch
Example 2

- Adding haptics to a prosthetic
- Feel sensations through the prosthetic
- Haptics is a 2-way interaction
  - Apply force
  - Expect feedback of the force ...
  - Feel it

- From DARPA prosthetics program
  28-old man
  Complex rewiring of cortex

UI Design

- There are principles of perception that apply too each of the senses
- Ignoring principles of perception can create dysfunctional information displays
- Knowledge of principles of perception helps to design effective information displays
- Knowledge of *Locus of Attention* and *Attention Variation* are important to interface design
Review #3

- Introduction to reasoning
- Principles of Reasoning
- Principles of Gestalt
- Principles of Human Vision/Hearing/Touch
  - (Perceptual) Color
  - Vision sub-systems
- Discussed in generic design context (not yet)
  - Color
  - Visual density and balance
  - Text legibility
- Discussed in InfoVis/design context (not yet)
  - Visualisation
  - Visual coding