5. Space & Movement

Up, up and away, in my beautiful balloon!

Brian Whitworth

Aim

How does the brain represent a 3D world?

How does this affect the design of HCI systems?

Recap - border contrast

- As border contrast information goes from eye to brain (Retina -> LGB -> Visual cortex)
- Visual system creates *progressive border enhancement*
- Border contrasts are good ways to convey information (e.g. C*)

Progress bar

Scroll bar

Contours

- For a 2D image, borders give it *shape*
- But for a 3D object borders give a *contour or outline,* which depends on its
  - *Form* - what it is
  - *Orientation* - our angle of view
  - *Position* - where it is in 3D space
- But optic nerve signals are from a *flat* surface (the retina)
- How can 2D information give a 3D perception?

Link: Art and visual abstraction

Art and contour abstraction

- Most of the information we get from a half-tone photo can be represented in a line drawing, i.e. from *contour abstraction*
- Artists often *begin* paintings with a line drawing
- Conclusions:
  - ***Seeing generates contour abstractions from sense pictures***
  - ***Artists generate pictures from contour abstractions***

Art as reverse visual processing

Seeing

REAL IMAGE → **CONTOUR ABSTRACTION**

Painting

The artist represents a scene of light and space by reduction to contours or contour abstraction. This gives the linear outlines of the scene. These are then filled with more detail, hatching or wash to represent light or shade, surface texture or color

Surface

- Realistic object surfaces have variations in hue, brightness, saturation, luminance and texture
- Also get areal contrast, brightness differences between *areas*
- Line drawings seem "dry" and unreal because they don't tap these channels (see previous lessons)
- Line drawings also seem "static"
- *Application: Use color/texture changes to add "feel" to surfaces*

Visual abstraction

- If the visual system abstracts high level contour color and texture information, **what other information abstraction occurs?**
- The artistic process suggests a second type of *visual abstraction* (or information reduction) - ***axis formation***
- *Recall*: Studies showed *orientation* was a neural channel apart from *color and shape*

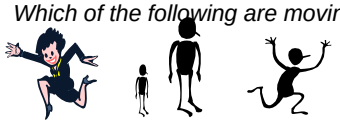
Axis formation

- Object *contours imply object form, i.e.* ***what it is***
- Structural *axes* imply *object structure, i.e.* ***what it is doing***
- Ignoring contours, and reducing an object to its structural axes, gives a *stick figure* that is very effective in showing *posture*

What's the matter?

Deducing actions from static images

- The *relationships* and *orientation of* structural axes allow us to deduce *posture*
- From certain postures we deduce *movement*
- See this 5,000 year old Neolithic art.
- *Which of the following are moving?*



How do you know?

Blurring contours

- When an object moves, its contours blur
- Artists "dissolve" or "vivify" contours to suggest dynamic movement

Application - blurring contours

- Generally don't blur contours
  - using shadow
  - embossed font effects
- If you must use such effects:
  - Use larger font size
  - Say less
  - Use simpler fonts
  - Use more color contrast

Don't do this!

Or this!

A Study Of HCI

HCI Review

Font Arial not TNR, larger, three not five words, black contrast

Link: Gibson

Flow lines

- *Line of movement* is another of an object's constant invariant properties (like color, size & form)
- We also abstract "flow lines" of motion e.g. pilots landing a plane
- Such flow lines represent movement direction

Application: Use flow lines to indicate line of movement

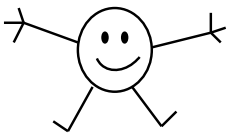
Drawing and minimalism

- Drawing is *the art of omission* (i.e. eliminating unnecessary information)
- Visual processing also *abstracts the relevant* information by reducing information to its essentials
- *Application:* If we understand what viewers actually process we can omit the rest
  - The smiley
  - Three fingered cartoon hands

Link: Children's drawings of people

Example - Children's drawings

- Pre-school children typically draw people as "tadpoles", i.e. they *attach limbs to the head*



It is a big advance when they add in the body (middle) part and attach arms and legs to that

Anchoring on the end points

- Children *anchor* on *end points* (face/limbs) as *key features* not the middle points (body), although the body part is largest!
- So they draw end-points *first* and *larger*, i.e. draw face first then legs (attached to the face)
- Only *years* later is it done correctl
- *Application*: In face caricatures, key features are exaggerated

Use abstract images (not realistic)

- Computer screens have *fewer pixels* than a book page & *much* fewer than a painting or movie
- There is *less* raw information to work with
- Also, the *usable screen* is not the *full screen*
- *Perceptual simplification* techniques, based on abstraction principles, *give the same effect for less*
  - Simplified images are easier to make, use less storage space and faster to download (e.g. Google)
  - Upload and download times are a problem and will be for the foreseeable future, esp in some countries

Example - SouthPark

- No noses (inessential)
- Head bigger than body
- Minimal body structure - legs & body one axis
- Simple contours
- A few bright colors
- No attempt at realism
- Yet appealing & popular

Visual space

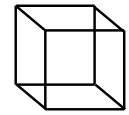
Link: Visual space

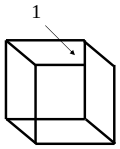
- How do we get 3D from 2D drawings?
- Because the eye normally uses 2D information from a flat retina surface to create 3D *visual space*
- ***visual space ≠ physical s***
- *Visual space is a deduction of the senses*
- *Hence illusions of depth*

Depth is deduced

Link: Necker cube

- *Necker cube* - if you look at different corners, the front becomes the back - it reverses
- We can make the whole irreversible by adding the intersection at 1
- But if you focus at the bottom right - it still reverses!
- Implies pre-conscious local analyzers





Monocular cues for depth

- *Shadows*
- *Overlapping* (occlusion)
- Increased outline *fuzziness*
- *Saturation* changes
- Relative size vs *known size*
- *Perspective* lines
- *Parallax* (moving head to a different angle)

Example

- A flat image has no variation in saturation

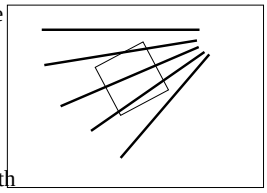
- A 3D image varies saturation, and parts of it are in shadow

Application: Use 3D cues to add another dimension or *channel of experience* to graphics

Depth illusions

Link: Emmerts law

- Depth illusions use (or misuse) these cues for depth
  - The perspective lines cue for depth
  - When the visual system adjusts the square for its (imagined) depth it no longer appears as square
  - Image size is reduced with increasing distance

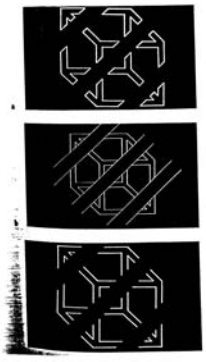


Example of size constancy

Example - occlusion and 3D

Link: Illusions

- *in a* we see flat shapes because each contour is closed (and that is the likely option)
- *in b* forming continuous lines highlights the 3D cube behind, which was always there, and could have been seen in a
- *in c* we *deduce* the lines from the edge discontinuities, and hence still see a cube covered by bars



Link: Stereoscopic depth

Stereoscopic cues for depth

- Each eye presents a slightly different view of the same scene (c.f. effect obtained by moving one eye - motion parallax)
- Matching such discrepancies requires *great neural computational power* - minor dot shifts are seen as depth cues
- *Application:* Virtual reality computers can simulate full 3D for a user with goggles (each eye gets a slightly shifted view)

Movement - a figure/ground deduction

- Like the vase/faces figure for shape, and the Necker cube for depth, movement information is actually *ambiguous*
- Could be the car or the background that moves!
- To *deduce* a car moves, we *assume* the background doesn't
- The *figure/ground distinction* is crucial to seeing movement

The computer "moves" the car by bitshifting the background pixels! see

A movement illusion

- If in a *stationary* car the car beside us moves
  - We may perceive *we* are sliding backwards
  - We may jam on the brakes frantically to no avail
    (as we are not moving, just seeing movement)
- When the *background* moves our visual system deduces *we* are moving
- We "see" the foreground object moving because it is the most likely deduction

Link: Perception of motion pictures

Representing motion

- Movie *frames* can represent motion because the eyes refresh less than 50 times a second
- If screen refreshes at more than 50Hz, it looks real - we cannot detect the 1/80th second when the screen is black
- *Application:* A sequence of static pictures can appear as motion, as the brain fills in the gaps to create "continuous" movement
- An animated GIF is a series of static pictures
  see How to Create an Animated GIF

The viewer

- We easily understand visual changes caused by camera movement because in real life our camera (the eye) is usually also moving:
  - *Panning*. Camera stationary, changing direction (rotating head)
  - *Zoom*. Changing camera focal length (focusing)
  - *Dolly shot*. Move in line of sight (LOS) direction (walking to)
  - *Track shot*. Move perpendicular to LOS (walking alongside)
- *Note:* Movies are still "passive" (see H7)

The "cut" - minimalism again

- Most motion picture cuts occur between views that do not overlap at all
- Perceptual deduction connects non-overlapping "cuts" (action views)
  (e.g. we see a car door opened, then a car drive away, and "fill-in" that the car was started, put in gear, etc)
- Modern directors "omit" much of a "real" action sequence, showing only *key events* (cf. anchoring on key features)
- Saves viewing time with no effect loss

Representing vs reflecting reality

- ***Repeat:*** It is not necessary to reproduce reality to create effective perceptions
- Artists and directors *represent* reality rather than *copy it,* by their understanding of people
- *WEB DESIGNERS SHOULD DO THE SAME* - result is more *efficient* and more *effective* sites
- This approach works because perception also *represents rather than reflects reality*

Link: Object perception

Summary - object properties

- Vision analyzes input via the constant object features of
  - *Form* (contour)
  - *Surface* (texture/color)
  - *Action* (axis/posture), and
  - *Momentum* (flow lines)
- It ignores changes due to:
  - *Orientation* (by object rotation)
  - *Position* (by object movement)
  - *Illumination* (by changing background light)
  - *Viewer position/orientation* (by viewer movement)
  - *Interference* (by other overlaid objects)
- The processing result is a *mental model* of the object world

Link: Image rotation

Example: Image rotation

- Objects pictured in the mind can be "rotated"
- There is a relation between the amount of rotation required and the mental time taken!
- We create (and use) a mental model of 3D space, and can move objects within it
- Mathematical problems can be solved by *spatial thinking* - e.g in elliptical geometry parallel lines can intersect (imagine two "parallel" lines on a sphere to see why)

Link: Mental imagery

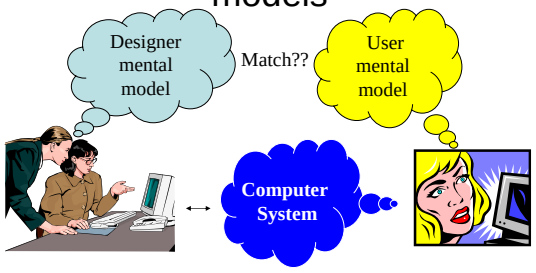
Mental models of space

- Imagine a 4cm cube painted red all over that is cut into many little 1cm cubes
- How many little cubes have
  - three red sides? 8 corners => 8
  - Two red sides? 12 edges x 2 => 24
  - One red side? 6 faces x 4 => 24
  - No red sides? Center 2x2 cube => 8
- Most people solve this using a mental image which they "cut" and then examine

Application: Use spatial models

- If people build a sophisticated mental model of 3D space - why not use it?
  - Cf the success of the desktop metaphor
  - Navigation of documents as navigation of space
  - Security as "doors" and "walls"
  - Passwords as "keys", a cursor as a "hand"
- Use existing user mental models to make systems "intuitive" (easy to learn and use)

Designer vs. User mental models



Designers and users have the same mental model for intuitive systems

Hemisphere specialization

- If the LH learns language, *what does the other equally powerful hemisphere do?*
- The RH specializes in *processing visual space* (for 95% of right handers and 70% of left handers)
- Are you right brained or left-brained or both?
  - Galton found intellectually gifted academics (left-brained) had weaker images (right brained)
  - Can you "see" detailed images in your mind? Are they colored? Do they move?
- Don't assume everyone else is like you

Appeal to both hemispheres

	Left Hemisphere Likes	Right hemisphere Likes
Processing	Deep logic structures time patterns	Broad structures spatial patterns
Cognitive style	Rational, sequential analytical, detail	Intuitive, holistic, artistic, gestalt
Task Specialty	Language, grammar, logic, arithmetic	Spatial, imagery, design, music, art
Focus	Semantic and intellectual content	Expressive & emotional content

*Application: Buttons with graphics **and** text (for both H's)*

Individual differences

- Individuals have different *channel/processing preferences*
  - some more left-brained, some more right
  - some prefer to see, some prefer to hear
  - some are conceptual, some must "do" to "know",
  - some prefer color, some ignore it
  - some focus on who (people), some on what (objects)
- **Individuals differ significantly in how they operate**
- *Application:* Support many channels and processes, i.e. a multi-media approach is more likely to work

Summary - Images that work

- Images that work trigger basic mechanisms of:
  - *boundary changes* (borders, edges)
  - *color & texture* gradients (surface)
  - *contour* and *shape* (form)
  - *axes* and *orientation* (structure and action)
  - *spatial position* (3D and depth)
  - *event sequence* (movement and actions)
- These *perceptions* are either seen or not seen

Principles summary

- Objects in space are mostly seen as contour lines
- Area contrasts also create boundaries
- Surfaces and their "feel" are color and texture
- Object structure/posture is represented by axes
- Movement and action can be represented by
  - Active structures or postures
  - Blurred or activated boundaries
  - Flow lines

Principles (ctd)

- Monocular depth involves shadows, saturation, occlusion, perspective lines, blurring and known size
- People anchor perceptions to key features, to image end-points not middle parts
- A logical sequence of static images is seen as movement (the mind "connects" the static images)
- A logical sequence of "scenes" is seen as a "story"
  (the mind "fills in" the gaps to form a continuous experience stream)
- A moving background is seen as movement of the foreground object

Principles (ctd)

- Spatial imagery is usually the specialization of an entire hemisphere
- Different people prefer different channels or processes when forming perceptions
- For efficient and effective presentations, omit things not needed for the perception
- Intuitive interfaces use existing mental models

Applications summary

- Don't blur typeface contours by shadow or 3D or embossed effects, unless large and clear text
- Make important area boundaries "sharp", especially internal ones - or leave them out
- To represent a posture and mood, enhance axes
- To represent an action use an action posture
- Use color and texture to add surface "feel"
- Add a dynamic feel to static images by vivifying contours and showing flow lines
- Indicate 3D space using monocular cues for depth (e.g. shadows, saturation gradients)

Applications (ctd)

- In faces the nose is not important - e.g. the smiley
- An animated GIF is just a set of static images
- A cartoon strip can present a story
- Always *combine* images and text, to give both hemispheres complementary processing (e.g. Netscape buttons are easier than Word buttons)
- The more processing channels used the more different people for which it will "work" - one channel excellence one will not please everyone
- *Balance* is better than *excellence - try to touch every base of user processing*

Homework – To Read

- Art and visual abstraction - a fascinating section
  - http://www.answers.com/topic/art-and-visual-abstraction
- Visual space - understand the model of space people create
  - http://en.wikipedia.org/wiki/Visual_space
- Stereoscopic depth -how the two eyes work together
  - http://en.wikipedia.org/wiki/Stereopsis
- Illusions- a very interesting section
  - http://brainden.com/visual-illusions.htm http://www.foontastic.com/illusion.html
- Children's drawings of humans - we all used to draw like this
  - http://psychology.jrank.org/pages/890/children%27s-drawings-human-figures.html
- Mental imagery - again the idea of mental models
  - http://www.answers.com/topic/eidetic-imagery
- Perception of motion pictures - a brief summary of a whole industry
  - http://psychology.jrank.org/pages/1160/films-perception.html
  - http://www.ctheory.net/articles.aspx?id=349

OTHER LINKS

- Art and Visual Abstraction
  - http://psychology.jrank.org/pages/743/1-Abstractions-contour-structure-movement.html
  - http://psychology.jrank.org/pages/748/6-Dynamic-linear-structures.html
  - http://books.google.co.nz/books?id=V2lhMORfIUAC&pg=PA414&lpg=PA414&dq=Perception+of+motion+pictures+perceptual+theories&source=bl&ots=leaZObLuKn&sig=AhD_ckMMjxO7J4rjOORAviAf_0s&hl=en&ei=I7IbTrC6Goe-sQPO--GjBQ&sa=X&oi=book_result&ct=result&resnum=10&ved=0CG
- Image Rotation
  - http://www.answers.com/topic/image-rotation
- Object Perception
  - http://www.answers.com/topic/object-perception
- Emmert's law
  - *http://en.wikipedia.org/wiki/Emmert%27s_law*
- *Necker Cube*
  - *http://en.wikipedia.org/wiki/Necker_cube*
  - *http://www.answers.com/topic/necker-cube-1*
- *Gibson*
  - *http://en.wikipedia.org/wiki/James_J._Gibson*

Next:

- The other senses
- Sound and its connection to emotions
- The scratch and sniff screen?
- Virtual reality chairs?