Plan for today
- 15 min: pitches details & project resources
- 45 min: Marks & Channels
  - mini-lecture
  - examples & discussion
  - further Q&A
- 15 min: Rules of Thumb, Design Study Methodology
  - further Q&A
  - (break: 10 min)
- 75 min small groups exercise: Decoding
  - 45 min breakout groups
  - 30 min: reportbacks

Next week
- to read & discuss (async, before next class)
  - VAD book, Ch. 7: Arrange Tables
  - paper: LineUp [technique]
  - paper: Partitioning Bar Mertices [technique]
- sync class: project pitches!
  - 2 min each
  - if already have full or partial team, can combine your times together
  - up to you prerecord video OR present live, need slides either way
  - due on Canvas by 1pm (Wed Sep 21)
  - prerecorded, video slides and slides
  - video creation tips/resources https://www.visualisingdata.com/resources/ (near-endline Q&A) / discussion through dedicated Piazza thread

Project resources: Datasets
- • many choices!
  - Data Is Plural: weekly newsletter of interesting/quirky datasets by Jeremy Singer-Vine
    - brings weekly loss
  - single source spreadsheet with everything
  - VASS Challenge: Learning Logs dataset
  - tools: you're free to pick platform
  - • tools: you're free to pick platform
  - • tools: you're free to pick platform
  - • many, many smaller building blocks
  - many more on Resources page
  - https://www.cs.ubc.ca/~tmm/courses/547-22/tools/

Project resources: Tools
- • Tools: you’re free to pick platform
  - align with current strengths? learn something new?
  - overview of the “big 4”: D3, R/tidyverse, Python, Tableau
  - consider covering your own strengths & goals in your pitch
  - smaller tools: also free to use
  - pitch details & project resources
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Project resources: Marks and Channels
- • marks
  - basic geometric elements
  - channels
  - control appearance of marks
  - https://www.cs.ubc.ca/~tmm/courses/547-22/tools/

Reduced encoding
- multiple channels
  - sends stronger message
  - but uses up channels

Marks: Constrained vs encodable
- math view: geometric primitives have dimensions
  - Points
  - Lines
  - Areas
  - 0D
  - 1D
  - 2D

Constraint view: mark type constrains what else can be encoded
- pattern: 0 constraints on size, can encode more attributes w/ size & shape
- lines: 1 constraint on size (length), can still size code other way (width)
- areas: 2 constraints on size (length/width), cannot size code or shape code
- quick check: can you size-code another attribute, or is size/shape in use?

Grouping
- marks
  - containment
  - connection

Marks: Attributes
- proximity
  - same spatial region
- similarity
  - same values across other categorical channels

Quiz: Name those marks & channels
- A: Shooting Media Coverage
- B: Tax Rates
- http://www.cs.ubc.ca/group/infovis/resources.shtml#data-repos
Idioms: pie chart, coxcomb chart

- **pie chart**
  - interlocking area marks with angle channel: 2D area varies
  - what type of mark?
    - line?
    - no, not length coded
    - point mark with rectangular shape?
    - yes!
    - area?
    - no, area/shape does not convey meaning

- **coxcomb chart**
  - invented by Florence Nightingale:
    - Diagram of the Causes of Mortality in the Army in the East
  - nonuniform width as length increases
  - 1D length varies
  - 2D area varies
  - 1D length: uniform width, so area is linear with line mark length
  - both radial & rectilinear cases

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- **15 min: Rules of Thumb, DSM Methodology**
- further DSM
- **break: 10 min**
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Visual encoding
• analyze idiom structure as combination of marks and channels

Marks for items
• basic geometric elements
  - Points
  - Lines
  - Interlocking Areas

Marks for links
• Containment
• Connection

Definitions: Marks and channels
• marks
  - geometric primitives
  - marks: represent items or links
  - channels: change appearance of marks based on attributes
  - points: encode more attributes w/ size & shape
  - lines: encode more attributes w/ size (length), can still size code other way (width)

Definitions: Marks and channels
• channels
  - control appearance of marks
  - visual variables
  - retinal channels
  - visual dimensions
  - perceptual system can be conveyed to human

Containment can be nested

[Untangling Euler Diagrams, Riche and Dwyer, 2010]

Marks as constraints
• math view: geometric primitives have dimensions
  - Points
  - Lines
  - Interlocking Areas

Marks as constraints
• constraint view: mark type constrains what else can be encoded
  - points: 0 constraints on size, can encode more attributes w/ size & shape
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Redundant encoding
• multiple channels
  - sends stronger message
  - but uses up channels

Length, Position, and Luminance

3D mark: volume, rarely used

Mark properties differ
• properties change appearance of marks
• type & amount of information that can be conveyed to human

Definitions: Marks and channels
• marks
  - geometric primitives
• channels
  - control appearance of marks
  - visual variables
  - retinal channels
  - visual dimensions
Separability vs. Integrality
- constraint: mark type constraints what else can be encoded
  - points: 0 constraints on size, can encode more attributes w/ size & shape
  - lines: 1 constraint on size (length), can still size code other way (width)
- interlocking areas: 2 constraints on size (length/width), cannot size or shape code
- quick check: can you size-code another attribute
  - or is size/shape in use?

Scope of analysis
- simplifying assumptions: one mark per item, single view
- later on
  - multiple views
  - multiple marks in a region (glyph)
  - some items not represented by marks (aggregation and filtering)

Channels: Rankings
- Expressiveness: match channel type to data type
- Effectiveness: some channels are better than others

Popout
- find the red dot
  - how long does it take?

Discriminability: How many usable steps?
- must be sufficient for number of attribute levels to show
- line: bandwidth

Channels: Rankings
- Position on common scale
  - spatial region
  - color hue
  - color saturation
- Area (3D position)
- Depth (3D position)
- Color luminance
- Color saturation
- Size
- Shape
- Volume (3D size)

Attributes
- Categorical Attributes
  - Identity
  - Shape
- Spatial Attributes
  - Spatial region
  - Position on unaligned scale
- Identity for categorical
- Cyclic
- Deriving
- Quantitative
- Sequential
- Diverging

Accuracy: Fundamental theory
- length is accurate: linear
- others magnified or compressed
  - -expansion characteristics

Accuracy: Vis experiments
- Contrast to background
- Contrast to edges

When to use which channel?
- Expressiveness
  - match channel type to data type
- Effectiveness
  - some channels are better than others

Channels: Rankings
- Position on common scale
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  - color hue
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- Area (3D position)
- Depth (3D position)
- Color luminance
- Color saturation
- Size
- Shape
- Volume (3D size)
Relative luminance judgements
• perception of luminance is contextual based on contrast with surroundings

Relative vs. absolute judgements
• perceptual system mostly operates with relative judgements, not absolute
– that's why accuracy increases with common frame/scale and alignment

Factors affecting accuracy
• alignment
• distractors
• distance
• common scale

Relative color judgements
• color constancy across broad range of illumination conditions
**Rules of Thumb**

- **No unjustified 3D**: Danger of depth
  - we don't really live in 3D: we see in 2.65D
  - acquire more info on image plane quickly from eye movements
  - acquire more info for depth slower, from head/body motion

- **Occlusion hides information**
  - occlusion
  - interaction can resolve, but at cost of time and cognitive load

- **Perspective distortion loses information**
  - perspective distortion
  - indifference with all size channel encodings
  - power of the plane is lost!

- **Unjustified 3D all too common, in the news and elsewhere**
  - Unjustified 3D examples:
    - Time-series data: extruded curves: detailed comparisons impossible
    - Economic growth curve: constrained navigation steps through carefully designed viewpoints
    - Economic growth curve: 3D legitimate for true 3D spatial data

**Depth vs power of the plane**

- planar spatial position: high-ranked channel!
- depth: not ranked!

**3D vs 2D bar charts**

- 3D bars very difficult to justify!
  - perspective distortion
  - occlusion
  - facing into 2D almost always better choice

**Tilted text isn’t legible**

- text legibility
  - far worse when tilted from image plane
  - further reading

**Justified 3D: Economic growth curve**

- constrained navigation steps through carefully designed viewpoints
- 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

**Justified 3D: shape perception**

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

**Perspective distortion loses information**

- perspective distortion
- indifference with all size channel encodings
- power of the plane is lost!
**Eyes beat memory**
- 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 states
  - poor for many states with changes everywhere
  - consider small multiples instead

**Why not animation?**
- disparate frames and regions comparison difficult
  - vs contiguous frames
  - vs small region
  - vs coherent motion of group
- safe special case
  - animated transitions

**Resolution beats immersion**
- overview first, zoom and filter, details on demand
- Why not animation?

**Change blindness**
- If attention is directed elsewhere, even drastic changes not noticeable
  - remember door experiment!
- change blindness demos
  - mask in between images

**Rule of thumb: Responsiveness is required**
- start with focus on functionality
  - possible to improve aesthetics later on, as refinement
- if expert in-house, find good graphic designer to work with
  - aesthetics do matter; another level of function
- visual hierarchy, alignment, flow

**Function first, form next**
- start with focus on functionality
  - possible to improve aesthetics later on, as refinement
- if expert in-house, find good graphic designer to work with
  - aesthetics do matter; another level of function
- visual hierarchy, alignment, flow
- Geeks principles in action
  - (not covered in this class)

**Form: Basic graphic design ideas**
- proximity
  - do group related items together
- alignment
  - avoid equal width boxes
- repetition
  - do only by using existing consistencies
- contrast
  - (not covered in this class)

**Best practices: Labelling**
- make visualizations as self-documenting as possible
  - meaningful & useful title, labels, legends
  - axes and panes/subwindows should have labels

**Methodology for problem-driven work**
- definitions
- 9-stage framework
- 32 pitfalls & how to avoid them
- comparison to related methodologies

**Animation: Blink comparator**
- just two contiguous frames is a special case: animation beats side by side
  - blink comparator used to discover Pluto

**Change blindness example: Cerebral**
- small multiples: one graph instance per experimental condition
  - same spatial layout
  - color differently by condition

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Lessons learned from the trenches: 21 between us

Design study methodology: definitions

9 stage framework

9-stage framework

Design study methodology: 32 pitfalls

• and how to avoid them
**Design study methodology: 32 pitfalls**

**PITFALL**  
Premature Design Commitment

Of course they need the cool technique I built last year!

**METAPHOR**  
Design Space

- Fellow tool builders
- Data promised

**EXAMPLE FROM THE TRENCHES**  
Premature Collaboration!

PowerSet Viewer  
2 years / 4 researchers

WikiVis  
0.5 years / 2 researchers

- Fellow tool builders
- Data promised

**PITFALL**  
Premature Collaboration!

Don't step on your own toes!

**EXAMPLE FROM THE TRENCHES**  
Horse Race vs. Music Debut

**PITFALL**  
Premature Publishing

I can write a design study paper in a week!

“writing is research”  
[Wolcott Writing up qualitative research, 2009]

**EXAMPLE FROM THE TRENCHES**  
Don't step on your own toes!

First design round published

Subsequent work not stand-alone paper

Technique-driven

Problem-driven

Must be first!

Am I ready?

Think broad!
Reflections from the stacks: Wholesale adoption inappropriate
• ethnography
  – rapid, goal-directed fieldwork
• grounded theory
  – not empty slate: background is key
• action research
  – aligned
  * intervention as goal
  * transferability not reproducibility
  * personal involvement is key
• opposition
  * translation of participant concepts into visualization language
• researcher lead not facilitate design
• orthogonal to vis concerns: participants as writers, adversarial to status quo, postmodernity